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RANGE REFERENCE ATMOSPHERE

FAIRBANKS

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APPLICATIONS CENTER

Scott Air Force Base, Illinois, 62225-5438

REVIEW AND APPROVAL STATEMENT

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13. Abstract: This range reference atmosphere (RRA) is a statistical model (derived from upper-air observations) of the atmosphere from 0 to 30 km over the Fairbanks range complex. The RRA provides tabulations of monthly and annual means, standard deviations, and skewness coefficients for wind speed, pressure, temperature, density, water vapor pressure, virtual temperature, and dew point temperature. It also gives means and standard deviation for the zonal and meridional wind components and hydrostatic model atmosphere. Methodology is included, along with graphic displays of wind statistics that can be derived from the wind data.

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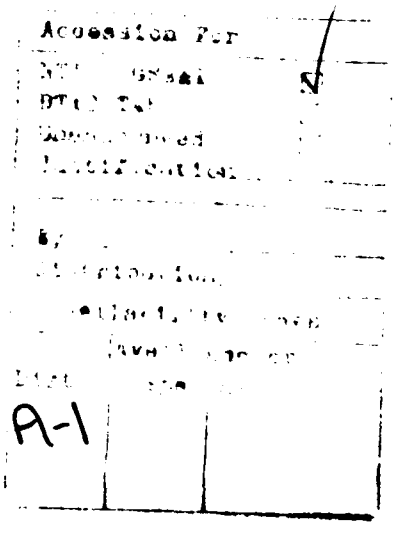

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PREFACE

The state of the atmosphere over national ranges and aerospace vehicle launch and/or recovery sites is critical not only to launch and recovery operations, but to aerospace research and development, as well. In the early 1960s, missile range operators recognized the need for a realistic atmospheric model that was consistently derived for each of the several major missile test ranges then in operation. Such a model, derived from climatological statistics for a given location, was developed and named a "range reference atmosphere." Even though the application has since broadened to include all aerospace launch and/or recovery sites, the model is still referred to as a "range reference atmosphere," or "RRA."

The first RRA (for Cape Canaveral) was prepared in 1963 by the Inter-Range Instrumentation Group (IRIG). More RRAs were produced for other ranges through 1974. Since then, improved upper-air databases have become available not only because of an extended period of record, but because of more and better rocketsonde data above 30 km. Although some improved RRAs were published in 1983 and 1984, revisions must continue, because:

- Aerospace technology requirements continue to change--the space shuttle program is an example.
- Extended and improved upper-air databases for most existing ranges permit development of better, more comprehensive RRAs.
- New launch and recovery sites have been opened.
- There have been significant advances in understanding the structure and physics of the upper atmospheric.
- There have been similar advances in statistical modeling techniques, largely because of ever-larger, faster, and more sophisticated computers.

For these reasons, the Range Reference Atmosphere Committee (RRAC) was tasked by the Range Commander's Council/Meteorology Group (RCC/MG) to produce new and revised RRAs, as required. The RRAC, through Task MG-1, publishes RRAs for ranges specified by the RRC. An RRA, as has already been mentioned, is a model of the atmosphere over a specified geographical area that delineates an aerospace vehicle launch and/or recovery site. RRAs are for use by DoD and other U.S. Government users in planning, evaluating, and establishing environmental launch/recovery constraints for a specific facility and the aerospace vehicles launched and/or recovered there.

The RRA tasking requires using the best available upper-atmosphere databases (rawinsonde, rocketsonde, and any other high-altitude data source) to create and publish (in standard format) a consistently derived model of wind and thermodynamic values through a cross-section of the upper atmosphere from surface to a specified height. The individual RRA serves as the authoritative source for upper-atmosphere climatology at a given launch/recovery site.

Wind statistics, insofar as practical, are modeled to be consistent with the rigorous mathematical probability properties of the multivariate normal probability theory. Thermodynamic statistics, insofar as practical, are modeled to be consistent with the hydrostatic equation, the equation of state, and related probability principles.

In keeping with the RCC's objective of standardization, modeling technique, basic text, and tabulation formats are is the same for all RRAs. RRAs published in 1990 have undergone minor format changes designed to make them conform to DoD and ANSI technical publications standards. All RRAs provide mean values of thermodynamic quantities (pressure, temperature, and density) and moisture quantities (vapor pressure, virtual temperature, and dew point temperature). These values include a statistical measure for the dispersion: that is, standard deviations and skewness coefficients. The properties of the bivariate normal probability distribution function are used for statistical modeling of wind.

The first RRA to be published in this new (1990) series was for the Wake Island Missile Range, with an altitude range from 0 to 30 km. The order of priority for subsequent publications in the RRA series is:

Range	Altitude Range Required
1. Nellis Range Complex, NV	0 - 30 km
2. Shemya, AK	0 - 70 km
3. Thule, GR	0 - 70 km
4. Fairbanks, AK	0 - 30 km

All final computations in this RRA series were performed by the USAF Environmental Technical Applications Center (USAFETAC) in response to taskings from the Ballistic Missile Office (BMO), HQ Air Weather Service (AWS/SYJ), and Detachment 2, Space Division.

Majors Cheryl Souders and Walter Miller, and Capts Doug Adamson and Brian Bjornson (all of USAFETAC/DNO), rewrote the software used to provide the primary tables, updated Chapters 1 through 4, and prepared the appendices. USAFETAC/LDE formatted and edited the text and graphics, prepared the camera-ready copy in standard DoD technical report format, and published the document as a USAFETAC project report.

The RRC/MG Range Reference Atmosphere Committee is made up of representatives from the Air Force, Army, NASA, Navy, and NOAA. The RRA committee members were:

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Mr D. Godwin (USAKA)
Ms J. Bailey (YPG)
Mr T.O. McIntire (YPG)
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Chapter 1

INTRODUCTION TO THE THE RANGE REFERENCE ATMOSPHERE (RRA)

1.1 THE RRA DEFINED.

A "reference atmosphere" is a statistical model of the earth's atmosphere, derived from upper-air observations over a specific location. The atmospheric models developed by the Range Reference Atmosphere Committee (RRAC) in response to a tasking by the Range Commander's Council/Meteorology Group (RCC/MG) and published by the Secretariat, Range Commander's Council (RCC) are called "Range Reference Atmospheres," or "RRAs." The first series of RRAs was published from 1963 to 1974, and a second series was issued in 1983 and 1984.

1.2 PURPOSE OF THE RRA.

The individual RRA is the authoritative source for upper-atmosphere climatology over the launch and/or recovery site for which it has been prepared. RRAs are used to plan, evaluate, and establish environmental launch contraints for aerospace vehicles launched from a particular location.

1.3 CONTENTS OF THE RRA.

RRAs contain tabulations for monthly and annual means, standard deviations, and skewness coefficients for wind speed, pressure, temperature, density, water vapor pressure, virtual temperature, and dew point temperature. They also provide means and standard deviations for zonal and meridional wind components and the linear (product moment) correlation coefficient between wind components. Statistical values are tabulated (at the station elevation) at 1-km intervals from sea level (MSL) to 30 km and at 2-km intervals from 30 to 70 km. Wind statistics begin at about 10 meters above station elevation, and continue at altitudes with respect to MSL thereafter. For ranges without rocketsonde measurements, RRAs terminate at 30 km; they may be extended upward, if necessary, when rocketsonde data from a nearby location can be made available.

1.4 UNITS OF MEASUREMENT USED IN RRAs.

All wind speeds are in meters per second (m/s). In all cases, the skewness coefficient and the correlation coefficient between wind components are unitless. Pressure (including water vapor pressure) is in millibars (mb). Temperature and virtual temperature are in kelvin (K). Density is in grams per cubic meter (gm/m^3). All altitudes are geometric, in kilometers (km). All heights are geopotential, also in kilometers (km). All altitudes/heights are in relation to mean sea level.

1.5 RRA QUALITY CONTROL.

Less than 10 percent of the soundings in the database used to calculate the RRA tables contained erroneous data. Soundings that did contain erroneous values data were eliminated from the database. Steps taken to produce an RRA that is as error-free as possible are described below:

(1) Soundings with gaps in their pressure levels of more than 200 mb were rejected. These soundings were eliminated because some contained height values only for mandatory pressure levels; when some heights at the mandatory levels were missing, the interpolated sounding contained significant errors.

(2) An initial set of RRA statistics was computed using all the remaining soundings (i.e., those that had not been rejected). This set was then used to determine data limits for temperature, pressure, U and V components of wind, density, and dew point for the 0-30 km portion, and density only from 30 to 60 km (in RRAs that go that high). The lower (or upper) data limits were set at the mean value for each variable, minus (or plus) six standard deviations of that quantity. One pair of data limits was computed for each of the atmospheric variables, the month, and the data level.

(3) The first set of data limits was then used to screen the database. All soundings that contained values outside the data limits were rejected. A new RRA was then computed using the screened database, and the second RRA was used to generate a second set of data limits.

(4) The second set of data limits was then used to screen the database further, and still another RRA was generated. The skewness values in this one were evaluated according to empirical criteria specified in Section 2.2 of this document (for winds) and in Section 3.2 (for thermodynamic quantities). If these criteria were satisfied, the third RRA was used to generate a final set of data limits, which were used to quality control the database for the final version of the RRA.

(5) Occasionally, the third RRA did not satisfy all the skewness criteria, indicating that the database still contained some erroneous values. To complete quality control, the "limits-to-RRA-to-limits" cycle was repeated (usually once or twice) until the resulting RRA satisfied the skewness criteria. When it did, a final set of data limits was generated, then used to quality control the database and produce the final RRA.

1.6 HOW THE RRA IS ORGANIZED.

RRA documents are published in four chapters, with Chapter 1 providing the introduction. Chapter 2, "Wind Statistics and Models," describes the techniques used to produce the wind statistics given in Table A-1 through A-13, Appendix A; it also describes the probability functions used as wind models to derive several wind statistics. Chapter 3, "Statistics of Thermodynamic Quantities and Models," describes the techniques used to produce the thermodynamic and moisture-related statistics in Tables B-1 through B-13 and C-1 through C-13, Appendices B and C. It also describes the atmospheric thermodynamic model in Tables D-1 through D-13, Appendix D. Chapter 3 also contains equations used to calculate several atmospheric properties. Chapter 4 provides conclusions and recommendations. Chapters 1-4 are the same in each new RRA; only Appendices A-G (described below) vary from RRA to RRA.

Appendix A contains monthly and annual wind statistics tables that give: (1) means and standard deviations of zonal and meridional wind components, (2) the linear (product moment) correlation coefficient between the two components, (3) the mean, standard deviation and skewness coefficient of the wind speed, and (4) the number of wind observations (sample size).

Appendix B contains monthly and annual thermodynamic statistics tables that give: (1) means, standard deviations, and skewness values of pressure, temperature, and density; and (2) the number of observations used for each of the thermodynamic quantities.

Appendix C contains monthly and annual moisture-related statistics tables that give: (1) means, standard deviations, and skewness values of water vapor pressure, virtual temperature, and dewpoint; and (2) the number of observations for each of the moisture-related quantities. Statistical values for water vapor pressure and dewpoint terminate at or below 15 km, depending on the range's latitude. Above 15 km, statistical values of virtual temperature are considered to be the same as those of temperature.

Appendix D contains monthly and annual tables that give hydrostatic model atmospheres for thermodynamic variables of pressure, virtual temperature, and density. Values are derived from the monthly and annual mean virtual temperature versus altitude (geometric) using the hydrostatic equation and the equation of state. Also presented is the geopotential height corresponding to the tabulated geometric altitudes.

Appendix E gives range-specific examples of certain wind statistics that can be derived from the basic data in Appendix A.

Appendix F gives tabular and graphic examples of certain pressure, density, and virtual temperature statistics that can be derived from basic data in Appendices B, C, and D.

Appendix G gives range-specific information such as location and database description.

1.7 CONVERSION UNITS.

Numerical values in the RRA are metric, as given in the International System of Units (SI, Systeme International d'Unites). Table 1-1 provides metric, U.S. Customary, and conversion units for all units used in this RRA.

TABLE 1-1. CONVERSION UNITS USED IN RRAs.

DATA TYPE	METRIC UNIT	ABBR	US CUSTOMARY UNIT	ABBR	CONVERSION: Multiply	By	To Get
Ambient Temperature	degree Celsius	^{o}C	degree Fahrenheit	^{o}F	$^{o}F-32$	0.5556	^{o}C
	kelvin	K	degree Rankine	^{o}R	^{o}C	1.8*	$^{o}F-32$
					^{o}R	1.00*	$^{o}F+459.67$
					$^{o}R-459.67$	1.00*	^{o}F
					K	1.00*	$^{o}C+273.15$
					K-273.15	1.00*	^{o}C
Temperature Change	degree Celsius	^{o}C	degree Fahrenheit	^{o}F	^{o}C or K	1.8*	chg $^{o}F/^{o}R$
	kelvin	K	degree Rankine	^{o}R	K or ^{o}R	0.5556	Chg $^{o}C/K$
Ambient Density	gram/cubic meter	gm^{-3}	grain/cubic foot	$grft^{-3}$	gm^{-3}	0.43700	$grft^{-3}$
Vapor Concentration	gram/cubic centimeter	gcm^{-3}			$grft^{-3}$	2.2883	gm^{-3}
(Absolute humidity)					gm^{-3}	10^{-6}*	gcm^{-3}
					gcm^{-3}	$4.370/10^{-5}$	$gcft^{-3}$
					$grft^{-3}$	$2.288/10^{-6}$	gcm^{-3}
Windspeed	meters/second	ms^{-1}	mile/hour	mph	ms^{-1}	2.2369	mph
			knots	knots	mph	0.44704*	ms^{-1}
			feet/second	fts^{-1}	ms^{-1}	1.9438	knots
					knots	0.51444	ms^{-1}
					mph	0.868976	knots
					knots	1.15078	mph
					ms^{-1}	3.2808	ms^{-1}
					fts^{-1}	0.3048*	ms^{-1}
Weight	gram	g	grain	gr	lb	0.45359237*	kg
	kilogram	kg	pound	lb	lb	453.59237*	g
					kg	2.20462	lb
					g	15.4324	gr
					gr	0.06480	g

TABLE 1-1. CONVERSION UNITS USED IN RRAS, *Cont'd.*

DATA TYPE	METRIC UNIT	ABBR	US CUSTOMARY UNIT	ABBR	CONVERSION: Multiply	By	To Get
Length	meter	m	feet	ft	m	3.2808	ft
	micron	μ	inch	in	ft	0.3048*	m
	Angstrom unit	A			in	$2.54\backslash10^{+4}$*	μ
					in	$2.54\backslash10^{+8}$*	A
					m	10^{+6}*	μ
					m	10^{+10}*	A
					μ	10^{-6}*	m
					μ	$3.937\backslash10^{-5}$	in
					A	10^{10}*	m
					A	$3.937\backslash10^{-9}$	m
Pressure	newton/square meter	newton m^{-2}	pound force/sq in	lb in^{-2}	mb	10^{-3}*	bar
					bar	10^{3}*	mb
	millimeter of Mercury	mmHg	inch of Mercury	mHg	newton m^{-2}	10^{-2}*	mb
					newton m^{-2}	$1.4504\backslash10^{-4}$	lb m^{-2}
					lb in^{-2}	$6.8948\backslash10^{3}$	newton m^{-2}
	bar	bar			mb	$1.4504\backslash10^{-2}$	lb m^{-2}
	millibar	mb			lbin^{-2}	68.948	mb
	dyne/square centimeter (microbar)	dyne cm^{-2}			mb	10^{3}*	dyne cm^{-2}
					dyne cm^{-2}	10^{-3}*	mb
	kilogram force/square meter	kg m^{-2}			lb in^{-2}	$6.8948\backslash10^{4}$	dyne cm^{-2}
					dyne cm^{2}	$1.4504\backslash10^{-5}$	lb m^{-2}
					mb	10.1972	kg m^{2}
					kg m^{-2}	0.0980665	mb
					lb m^{-2}	703.0696	kg m^{2}
					kg m^{-2}	0.0014223	lb m^{2}
					mb	$2.9530\backslash10^{-2}$	mHg (32°F)
					mb	0.75006	mmHg (0°C)
					mHg	25.40	mmHg (0°C)
					mmHg	1.3332	mb
					mHg (321)	33.8639	mb
	pascal				Pa	1.00*	newton m^{-2}

Chapter 2

WIND STATISTICS AND MODELS

2.1 GENERAL DISCUSSION.

One of the objectives in developing an RRA is to describe the wind field over the launch/recovery site as completely as possible with as few data tabulations as possible. With that in mind, the bivariate normal probability distribution was adopted as a statistical model for wind treated as a vector quantity at RRA data levels. Only five statistical parameters are required to completely describe this probability function; in Cartesian coordinates, these parameters are the means and standard deviations of the two orthogonal components, along with the correlation coefficient between the two components. The tables in Appendix A give the five statistical parameters for the zonal and meridional (meteorological coordinate) components. The statistical properties of the bivariate normal probability distribution are used to derive many wind statistics of interest to range users. The procedure produces consistent wind statistics that are connected through rigorous mathematical probability functions. By using these functions, extensive tabulations of wind statistics are avoided. Statistical properties of the bivariate normal probability distribution presented for the vector wind statistical model are:

- Wind components are univariate normally distributed.
- Conditional distribution of one component, given a value of the other component, is univariate normally distributed.
- Wind speed is in the form of a generalized Rayleigh distribution.
- Frequency distribution of wind direction can be derived.
- Conditional distribution of wind speed, given a value of wind direction (wind rose), can be derived.
- The five tabulated wind statistical parameters that are with respect to the meteorological zonal and meridional coordinate system can be derived for any arbitrary rotation of the orthogonal axes.

The RRA provides probability distribution functions and sets of equations to derive wind statistics for the previously stated properties of the vector wind model; examples are given in Appendix E.

No attempt is made here to give the derivation of the probability functions, but the reader is referred to Smith (1976) for derivations and several applications of the probability distribution properties for wind statistics.

Symbols used in Chapter 2, and their meanings, are given in Table 2-1, next page.

TABLE 2-1 Symbols Used In Chapter 2.

N	The number of wind measurements in Appendix A.
r	A general variable for the bivariate normal probability distribution in polar coordinates.
R	A generalized Rayleigh variable used for derived wind speed probability distribution.
$R(U,V)$	The linear (product moment) correlation coefficient between the zonal and meridional wind components in Appendix A.
$SK(W)$	Skewness parameter for wind speed in Appendix A.
$S(U)$	The standard deviation of the zonal wind component in Appendix A.
$S(V)$	The standard deviation of the meridional wind component in Appendix A.
$S(W)$	The standard deviation of wind speed in Appendix A.
t	A standardized normal variate used in Table 2-1.
U	The zonal wind component.
$UBAR$	The mean value of the zonal wind component in Appendix A.
V	The meridional wind component.
$VBAR$	The mean value of the meridional wind component in Appendix A.
W	Wind speed or modulus of wind vector, a scalar quantity.
$WBAR$	The mean value of wind speed in Appendix A.
X	A general component mean value in the $[X,Y]$ coordinate system.
Y	A general component mean value in the $[X,Y]$ coordinate system.
$\bar{X}$	A general component variable or coordinate axes.
$\bar{Y}$	A general component variable or coordinate axes.
α	(alpha) Rotation angle for the $[X,Y]$ coordinate system.
θ	(theta) Wind direction in the polar coordinate system.
λ	(Lambda) A parameter in the bivariate normal probability distribution in Table 2-2.
ξ	(Xi) The mean value in the standardized normal probability distribution used in Table 2-1.
π	(Pi) Constant = 3.14159 .
ρ	(Rho) The general linear correlation coefficient between the two component variables in the $[x,y]$ coordinate system
σ_x, σ_x	The general standard deviations of the x and y component variables in the $[x,y]$ coordinate system.

2.2 QUALITY CONTROL.

The U and V components of wind were used to generate data limits, which were set at plus and minus six standard deviations from the mean for each of the quantities. These data limits were used to screen the wind database, as described in Paragraph 1.5. The database was considered to be error-free if:

- The skewness of the wind speed was below 4.0 at data levels where the mean wind speed was less than 15 m/s, and

- The skewness of the wind speed was below 2.5 at data levels where the mean wind speed was greater than 15 m/s.

2.3 DATA LIMITATIONS.

For wind statistics, correlation coefficients for like and unlike wind components between altitude levels were not computed, and wind statistics with respect to altitude (profile) cannot be derived from RRA statistics; users are referred to Smith (1976) for wind profile modeling techniques. Wind statistics at discrete altitudes are valid; all the probability distribution functions described in Chapter 2 can be derived from the five wind component statistical parameters in Appendix A and the derived distributions can be considered as wind models at discrete altitudes.

Greek letters are used conventionally for population or theoretically known statistical elements, and sample estimates are denoted by English letters or with a "hat" ($\wedge$) over Greek letters. In Chapter 2, Greek letters are used for variances and linear correlation coefficient, while means are denoted by $\bar{X}$ and $\bar{Y}$ when dealing with the bivariate normal distribution. It must always be understood that Appendix A contains sample estimates of statistical parameters, and that they are with respect to the meteorological zonal (U) and meridional (V) coordinate systems.

2.4 THE COORDINATE SYSTEM OF STATISTICAL PARAMETERS.

Wind is measured and recorded in terms of magnitude and direction. Wind direction is expressed in degrees clockwise from true north, and is the direction from which the wind is blowing. Wind magnitude (the modulus of the vector) is the scalar quantity, and is referred to as wind speed or scalar wind. A statistical description that accounts for the wind as a vector quantity is appropriate and requires a coordinate system.

For the RRA, the Standard Meteorological Coordinate System has been chosen for wind statistics, all tables of statistical parameters, and related discussions. This choice was made because the coordinate system used in aerospace and related applied fields has not always been consistent. Figure 2-1 illustrates the Standard Meteorological Coordinate System.

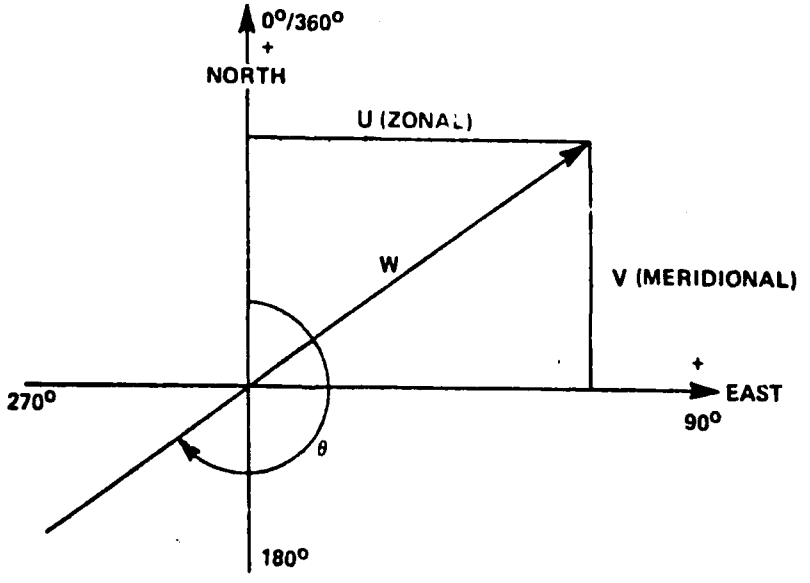

Figure 2-1. The Standard Meteorological Coordinate System.

Using Figure 2.1, the polar and Cartesian forms for the meteorological coordinate system are defined as follows:

W wind speed, scalar wind, or magnitude of the wind vector (m/s).

θ wind direction, measured as the direction *from which* the wind is blowing, in degrees clockwise from true north.

U zonal wind component, positive west to east (m/s).

V meridional wind component, positive south to north (m/s).

The components θ and W define the polar form, and the U-V components define the Cartesian forms:

$$U = -W \sin\theta, \quad 0 \leq \theta \leq 360^\circ \tag{1}$$

$$V = -W \cos\theta \tag{2}$$

It is helpful to note the difference between the *mathematical* convention for *vector* direction and the *meteorological* convention for *wind* direction:

$$\theta\, met = 270 - \theta\, math \tag{3}$$

$$\text{when } 0 \leq \theta \leq 270^\circ$$

$$\theta\, met = 360 + (270 - \theta\, math)$$

$$\text{when } 270 \leq \theta \leq 360^\circ$$

2.5 COMPUTING STATISTICAL PARAMETERS.

All these statistical parameters are with respect to the Standard Meteorological Coordinate System shown in Figure 2-1. The wind statistical parameters in Appendix A (means and standard deviations of zonal and meridional wind components, plus wind speed and the skewness parameter of wind speed) were computed using the sums technique described in Paragraph 3.5.1. In addition, a linear (product moment) correlation coefficient between the zonal and meridional wind components, $r\,(u,v)$ in Appendix A, was computed. This correlation coefficient is defined as:

$$r\,(u,v) = \frac{\sum_{i=1}^{n} (U_i - \overline{U})\,(V_i - \overline{V})}{N\, s(u) \cdot s(v)} \tag{4}$$

2.6 STATISTICAL WIND MODELS.

2.6.1 Wind Component Statistics.

The univariate normal (Gaussian) probability distribution function is used to obtain wind component statistics. In generalized notations, the probability density function (*pdf*) is:

$$F\,(T) = \frac{e^{-\frac{t^2}{2}}}{\sqrt{2\pi}} \tag{5}$$

where $t = X - \frac{\xi}{\sigma_x}$ is the standardized variate, with ξ defining the mean and σ the standard deviation.

The probability distribution function (*PDF*) is:

$$F(t) = \int_{-\infty}^{t} f(t)\, dt \tag{6}$$

Because this integral cannot be obtained in closed form, it is widely tabulated for zero mean and unit standard deviation. Selected values of $F(t)$ are given in Table 2-2, next page. To emphasize the connotation of probability, $F(t)$ is shown in Table 2-2 as $P\{X\}$. The t values in Table 2-2 are used as multiplier factors to the standard deviation to express the probability that a normally distributed variable (X) is less than or equal to a given value as:

$$P\{X \leq mean + t\,\sigma_x\} = probability, p \tag{7}$$

For example, when $t = 1.6449$, the probability that X is less than or equal to the mean plus 1.6449 standard deviations is 0.95. That value of X which is less than or equal to the mean plus 1.6449 standard deviations is called the "95th percentile value of X." Also given in Table 2-2 are the numerical values for expressing the probability that X falls in the interval X_1 and X_2; i.e.,

$$P\{X_1 \leq X \leq X_2\} = \text{Interpercentile Range} \tag{8}$$

where

$$X_1 = \bar{X} - t\,\sigma_x$$
$$X_2 = \bar{X} + t\,\sigma_x$$

For $t = 1.9602$ the probability that X lies in the interval X_1 and X_2 is 0.95. The values of X_1 and X_2 in this example comprise the 95th interpercentile range.

For a normally distributed variable, the mode (most frequent value) and the median (50th percentile value) are the same as the mean value. The means and standard deviations of the zonal and meridional wind components from Appendix A are used in equations 7 and 8 to compute the percentile values and interpercentile ranges of the zonal and meridional wind components. When equation 7 is illustrated on a normal probability graph, a straight line is formed.

2.6.2 The Vector Wind Model.

Because wind is a vector quantity having direction and magnitude that can be expressed as two components in an orthogonal coordinate system, a probability model that describes the joint relationship is the bivariate normal probability distribution. In general component notation (shown by equation 9, below), the bivariate normal probability density function (*BNpdf*) is:

$$f(X,Y) = \frac{1}{2\pi\sigma_x\sigma_y\sqrt{1-\rho^2}}\left[exp\ \frac{-1}{2(1-\rho^2)}\left\{\frac{(X-\bar{X})^2}{\sigma_x^2} - \frac{2\rho(X-\bar{X})\,(Y-\bar{Y})}{\sigma_x\sigma_y} + \frac{(Y-\bar{Y})^2}{\rho_y^2}\right\}\right] \quad -\infty \leq X \leq \infty\ \&\ -\infty \leq Y \leq \infty)$$

where the five parameters are $\bar{x}, \bar{y}$, the component means σ_x, σ_y, the component standard deviations, and ρ, the correlation coefficient between the two component variables X and Y.

For many applications, there is interest in determining the probability that a point $\{X,Y\}$ will fall within a contour of equal probability density. The exponential terms of equation 9, when set equal to a constant (λ_2), give a family of ellipses depending on the value of the constant. The ellipses have a common center at the point $\{\bar{X},\bar{Y}\}$. Integration of equation 9 over the region bounded by the contours of equal probability density gives:

TABLE 2-2. Values of *t* for Standardized Normal (Univariate) Distribution for Percentiles and Interpercentile Ranges.

t	P(X)	X	$P\{X_1 \leq X \leq X_2\}$ (%)
-3.0000	0.00135	$\xi - 3.0000\ \sigma$	99.73 (0.27)
-2.5758	0.00500	$\xi - 2.5758\ \sigma$	99 (1.00)
-2.3263	0.01000	$\xi - 2.3263\ \sigma$	98 (2.00)
-2.2365	0.01266	$\xi - 2.2365\ \sigma$	97.468 (2.532)
-2.0000	0.02275	$\xi - 2.0000\ \sigma$	95.45 (4.55)
-1.9602	0.02500	$\xi - 1.9602\ \sigma$	95 (5)
-1.6449	0.05000	$\xi - 1.6449\ \sigma$	90 (10)
-1.2816	0.10000	$\xi - 1.2816\ \sigma$	80 (20)
-1.0000	0.15866	$\xi - 1.0000\ \sigma$	68.268 (31.732)
-0.8416	0.20000	$\xi - 0.8416\ \sigma$	60 (40)
-0.6745	0.25000	$\xi - 0.6745\ \sigma$	50 (50)
-0.2533	0.40000	$\xi - 0.2533\ \sigma$	20 (80)
0.0000	0.50000	ξ	
0.2533	0.60000	$\xi + 0.2533\ \sigma$	
0.6745	0.75000	$\xi + 0.6745\ \sigma$	
0.8416	0.80000	$\xi + 0.8614\ \sigma$	
1.0000	0.84134	$\xi + 1.0000\ \sigma$	
1.2816	0.90000	$\xi + 1.2816\ \sigma$	
1.6449	0.95000	$\xi + 1.6449\ \sigma$	
1.9602	0.97502	$\xi + 1.9602\ \sigma$	
2.0000	0.97725	$\xi + 2.0000\ \sigma$	
2.2365	0.98734	$\xi + 2.2365\ \sigma$	
2.3263	0.99000	$\xi + 2.3263\ \sigma$	
2.5758	0.99500	$\xi + 2.5758\ \sigma$	
3.0000	0.99865	$\xi + 3.0000\ \sigma$	

where $X_1 = \xi - t\sigma$
and $X_2 = \xi + t\sigma$

$$P(\lambda) = 1 - e^{\frac{-\lambda^2}{2(1-\rho^2)}} \tag{10}$$

Solving for λ^2 and replacing $P(\lambda)$ by p gives:

$$\lambda^2 = -2(1-\rho^2)\ ln(1-p) \tag{11}$$

Now define:

$$\lambda_e = \sqrt{2}\ \sqrt{-ln(1-p)} \tag{12}$$

For reference and comparison, λ_c. is shown in Table 2-3 for selected values of p.

TABLE 2-3. Values of λ for Bivariate Normal Distribution Ellipses and Circles.

P(%)	(λ_e--ellipse)	(λ_c--circle)	P(%)	(λ_e--ellipse)	(λ_c--circle)
0.000	0.0000	0.0000	65.000	1.4490	1.0246
5.000	0.3203	0.2265	68.268	1.5151	1.0713
10.000	0.4590	0.3246	70.000	1.5518	1.0973
15.000	0.5701	0.4031	75.000	1.6651	1.1774
20.000	0.6680	0.4723	80.000	1.7941	1.2686
25.000	0.7585	0.5363	85.000	1.9479	1.3774
30.000	0.8446	0.5972	86.466	2.0000	1.4142
35.000	0.9282	0.6563	90.000	2.1460	1.5175
39.347	1.0000	0.7071	95.000	2.4477	1.7308
40.000	1.0108	0.7147	95.450	2.4860	1.7579
45.000	1.0935	0.7732	98.000	2.7971	1.9778
50.000	1.1774	0.8325	98.168	2.8284	2.0000
54.406	1.2533	0.8862	98.889	3.0000	2.1213
55.000	1.2637	0.8936	99.000	3.0348	2.1460
60.000	1.3537	0.9572	99.730	3.4393	2.4320
63.212	1.4142	1.0000	99.9877	4.2426	3.0000

The probability ellipse that contains p-percent of the wind vectors expressed in the most general form is the conic defined by:

$$A X^2 + BXY + C Y^2 + DX + EY + F = 0 \tag{13}$$

Where: $A = \sigma_y^2$ $\quad D = 2\sigma_x\sigma_y\ \rho\bar{Y} - 2\sigma_y^2\bar{X} = -(B\bar{Y} + 2A\bar{X})$

$B = -2\rho\sigma_x\sigma_y$ $\quad E = 2\sigma_x\sigma_y\ \rho\bar{X} - 2\sigma_x^2\bar{Y} = -(B\bar{X} + 2C\bar{Y})$

$C = \sigma_x^2$ $\quad F = A\bar{X}^2 + C\bar{Y}^2 + B\bar{X}\bar{Y} - AC\ (1-\rho^2)\ \lambda_e^2$

and $\lambda_e = \sqrt{2}\ \sqrt{-ln\ (1-\rho)}$

For graphic presentations, the range of the variable is important in order to arrange the scale. The largest and smallest values of X and Y for a given probability ellipse (p) are given by:

$$X_{L,S} = \bar{X} \pm \sigma_x \lambda_e \tag{14}$$

$$Y_{L,S} = \bar{Y} \pm \sigma_y \lambda_e \tag{15}$$

where, as before, $\lambda_e = \sqrt{2}\ \sqrt{-\ln(1-\rho)}$

Although there are several approaches to graphing the probability ellipses, the following procedure is best for electronic computer plotting. In establishing the computer plotting program, the sample estimates for $\bar{X}$, $\bar{Y}$, σ_x, σ_y, and ρ are constants in equation 13. The user makes the choice of probability ellipses desired. Thus, p in equation 12 is programmed as a parameter. The largest and smallest values for X and Y are computed by equations 14 and 15 for the largest probability ellipse selected. This sets the graphical scale. Values of X within the range of X smallest to X largest are obtained by incrementing X between these limits. Using the quadratic equation, a solution of equation 13 is made for Y for each value of X, and plotted. The centroid $(\bar{X},\bar{Y})$ for the family of probability ellipses is plotted as a point. Labeling and other identification completes the plotting program.

For a given probability, equation 13 defines an ellipse that contains p-percent of the points X,Y. Since the entire area under the bivariate normal density function (equation 9) is unity, upon integration for a given probability ellipse, that given ellipse contains p-percent of the total area. In the wind statistics p-percent of the wind vectors fall within the specified probability ellipse. From this point of view, a specified probability ellipse gives the joint probability that p-percent of the U-V components lie within the given ellipse.

When $\sigma_x^2 = \sigma_y^2 = \sigma^2$ and $\rho = 0$ in the bivariate normal distribution, the probability ellipses of equation 13 reduce to circles whose centers are at the means $\bar{X},\bar{Y}$. The radii of the probability circles are $\sigma_{V1}\lambda_c$, where:

$$\sigma_{V1} = \sqrt{2\sigma^2} \tag{16}$$

and

$$\lambda_c = \sqrt{-\ln(1-p)} \tag{17}$$

Values for λ_c for selected probabilities, p, are given in Table 2-3.

Because this function is simple, it can easily be graphed manually. However, the generalized plotting technique for electronic computer plotters (as shown by equation 13) can be also be used.

2.6.3 Derived Distributions for Wind Statistics.

In this section, the probability distribution functions and sets of equations are presented to derive certain probability distribution functions for wind statistics. These derived probability distributions are:

- Conditional distribution of wind components
- Generalized Rayleigh distribution for wind speed
- Distribution for wind direction
- Conditional distribution of wind speed given a wind direction (wind rose).

The five required statistical parameters for these derived distributions for wind statistics are given in Appendix A.

2.6.3.1 The Conditional Distribution of Wind Components.

Given that two random variables X and Y are bivariate normally distributed, the conditional distribution $f(Y|X)$ is read as $f(Y)$ given X, and likewise $f(X|Y)$ is read as $f(X)$ given Y. The conditional probability function $F(Y/X)$ has the mean $E(Y/X)$ and variance $\sigma^2_{(x|y)}$, where:

$$E(Y|X*) = \overline{Y}n + \rho\left(\frac{\sigma_y}{\sigma_x}\right)(X* - \overline{X}) \tag{18}$$

and

$$\sigma^2_{(y|X*)} = \sigma_y^2\,(1-\rho^2) \tag{19}$$

The conditional standard deviation is:

$$\sigma_{(y|x*)} = \sigma_y\,\sqrt{1-\rho^2} \tag{20}$$

By interchanging the variables and parameters, the conditional distribution function for $F(X/Y*)$ has the conditional mean:

$$E(X|Y*) = \overline{X} + \rho\left(\frac{\sigma_x}{\sigma_y}\right)(Y* - \overline{Y}) \tag{21}$$

conditional variance:

$$\sigma^2_{(x|y*)} = \sigma_x^2\,(1-\rho^2) \tag{22}$$

and conditional standard deviation:

$$\sigma_{(x|y*)} = \sigma_x\sqrt{1-\rho^2} \tag{23}$$

The preceding conditional probability distribution functions are univariate normal distributions for a (fixed) given value for one of the bivariate normal variables. Thus, the t-values given in Table 2 are applicable for conditional probabilities statements. For example,

$$F(Y|X*) = E(Y|X*) + t\,\sigma_{(y|x*)} \tag{24}$$

For $t = 1.6449$, there is a 95 percent chance that Y is less than or equal to $\overline{Y} + 1.6449\,\sigma_{(y|x*)}$ given that $X = X*$. In symbols, this statement reads:

$$P\{Y \leq E(Y|X*) + 1.6449\,\sigma_{(y|x*)}|X = X*\} = 0.9500 \tag{25}$$

Interval probability statements can also be made:

$$P\{Y_1 = E(T|X*) - t\,\sigma_{(y|x*)} \leq Y \leq Y_2 = E(Y|X*) + t\,\sigma_y\ |X = X*\}$$

where $X*$ can take on any fixed value of X, but a convenient arrangement is to let $X* = \overline{X} \pm t\,\sigma_x$.

The close connection of the regression function of Y on X to the conditional mean for the bivariate normal distribution is noted:

$$Y = \bar{Y} + \rho \left(\frac{\sigma_y}{\sigma_x} \right) (X - \bar{X}) \tag{26}$$

Similarly, the regression function of X on Y is:

$$X = \bar{X} + \rho \left(\frac{\sigma_y}{\sigma_x} \right) (Y - \bar{Y}) \tag{27}$$

These are linear functions and express the same results as would be obtained from a least-squares regression line.

2.6.3.2 Generalized Rayleigh Distribution for Wind Speed.

If two random variables, X and Y, are bivariate normally distributed, then the probability distribution for the modulus, R, can be derived in terms of the five parameters that define the bivariate normal distribution:

$$R = \sqrt{X^2 + Y^2} \tag{28}$$

The distribution of R so derived is called a generalized Rayleigh distribution because there are no restrictions on the parameters. For applications to the RRA, the variable R is recognized as wind speed or the modulus of the wind vector.

The probability density function for R is expressed as:

$$f(R) = a_0 R e^{-a_1 R^2} \left[I_0(a_2 R^2)\, I_0(a_3 R) + 2 \sum_{k=1}^{\infty} I_k(a_2 R^2)\, I_{2k}(a_2 R)\, \cos 2k\psi \right] \quad R \geq 0 \tag{29}$$

The functions $I_0(\cdot)$, $I_k(\cdot)$, and $I_{2k}(\cdot)$ are the modified Bessel function of the first kind for zero order, kth order, and $2k$th order. The coefficients are:

$$\frac{a_0 = exp\left[-\frac{1}{2} \left\{ \frac{\bar{X}^2}{\sigma_a^2} + \frac{\bar{Y}^2}{\sigma_b^2} \right\} \right]}{\sigma_a \sigma_b}$$

where σ_a^2 and σ_b^2 are the rotated variances to produce zero correlation between X and Y. σ_a and σ_b are the positive and negative roots of the following expression, the computational form of which is obtained from the determinant:

$$\begin{vmatrix} \sigma_x^2 - K & \sigma_x \sigma_y \rho \\ \sigma_x \sigma_y \rho & \sigma_y^2 - K \end{vmatrix}$$

where K is $\sigma^2_{(+,-)}$, and σ_a and σ_b are analogous to the standard deviation of the major and minor axes of the bivariate normal probability ellipse:

$$\sigma^2_{(+,-)} = \frac{1}{2} \left\{ \sigma_x^2 + \sigma_y^2 \pm \left[(\sigma_x^2 + \sigma_y^2)^2 - 4\sigma_x^2 \sigma_y^2 (1 - \rho^2) \right]^{\frac{1}{2}} \right\}$$

$$a_1 = \frac{(\sigma_x^2 + \sigma_y^2)}{4(1-\rho^2)\ \sigma_x^2 \sigma_y^2}$$

$$a_2 = \frac{\left[(\sigma_x^2 - \sigma_y^2)^2 + 4\rho^2 \sigma_x^2 \sigma_y^2\right]^{\frac{1}{2}}}{4(1-\rho^2)\ \sigma_x^2 \sigma_y 2}$$

$$a_3 = \left[\left(\frac{\bar{X}}{\sigma_a^2}\right)^2 + \left(\frac{\bar{Y}}{\sigma_b^2}\right)^2\right]^{\frac{1}{2}}$$

and

$$tan\ \psi = \frac{\bar{Y}}{\bar{X}}\ \frac{\sigma_a^2}{\sigma_b^2}$$

Since this density function cannot be integrated in closed form from zero to R, numerical integration is used to obtain practical results from the probability distribution function; i.e.,

$$F(R) = \int_0^{R*} f(R)\, dR \tag{30}$$

A number of special cases can be obtained from the general Rayleigh distribution (equation 29), the most simple of which is to let $\sigma_x \equiv \sigma_y = \sigma$ and $\bar{X} = \bar{Y} = 0$ with independent variables X and Y. This gives:

$$f(R) = \frac{R}{\sigma^2}\ e^{\frac{-R}{2\sigma^2}} \tag{31}$$

which is recognized as the classical Rayleigh probability density function. The density function (equation 31) can be integrated in closed form over any range of the variable R. Hence, the probability distribution function, F(R), for equation 31 is:

$$F(R) = 1 - exp\left\{\frac{-R^2}{2\sigma^2}\right\} \tag{32}$$

2.6.3.3 The Derived Distribution of Wind Direction.

Considering the wind as a vector quantity and bivariate normally distributed, the wind direction can be derived. This is done by first writing the bivariate normal probability density function in polar coordinates whose variables are:

$$g(r,\theta) = r\, d_1\, e^{\frac{1}{2}(a^2 r^2 - 2br + c^2)} \tag{33}$$

NOTE: The expression in equation 33 (Smith, 1976) is given with respect to the mathematical convention for a vector direction, where:

$$a^2 = \frac{1}{(1-\rho^2)}\left[\frac{sin^2\theta}{\sigma_x^2} - \frac{2\rho\ cos\ \theta\ sin\ \theta}{\sigma_x\ \sigma_y} + \frac{cos^2\ \theta}{\sigma_y^2}\right]$$

$$b = \frac{-1}{(1-\rho^2)}\left[\frac{\bar{x}\ sin\ \theta}{\sigma_x^2} - \frac{\rho\ (\bar{x}\ cos\ \theta + \bar{y}\ sin\ \theta)}{\sigma_x \sigma_y} + \frac{\bar{y}\ cos\ \theta}{\sigma_y^2}\right]$$

$$c^2 = \frac{1}{(1-\rho^2)}\left[\frac{\bar{x}^2}{\sigma_x^2} - \frac{2\rho\, xy}{\sigma_x\,\sigma_y} + \frac{\bar{y}^2}{\sigma_y^2}\right]$$

$$d_1 = \frac{1}{2\pi\sigma_x\sigma_y\sqrt{1-\rho^2}}$$

and $r = \sqrt{x^2 + y^2}$ is the modulus of the vector or speed and θ is the direction of the vector. After integrating $g(r, \theta)$ over $r = 0$ to ∞, the probability density function is θ is:

$$g(\theta) = \frac{d_1}{a^2}\, e^{-\frac{1}{2}c^2}\left[1 + \sqrt{2\pi}\,\left(\frac{b}{a}\right)^2\,\Phi\left(\frac{b}{a}\right)\right] \tag{34}$$

where a^2, b, c^2, and d_1 are as previously defined in equation 33, and

$$\Phi\left(\frac{b}{a}\right)\;\Phi(x) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x} e^{-\frac{1}{2}t^2}\,dt$$

is taken from tables of normal distribution functions or made available through a computer subroutine.

If desired, equation 34 can be integrated numerically over a chosen range of θ to obtain the probability that the vector direction will lie within the chosen range; i.e.,

$$F(\theta) = \int_{\theta_2}^{\theta_1} g(\theta)\, d\theta \tag{35}$$

One application may be to obtain the probability that the wind will flow from a given quadrant or sector as, for example, onshore.

2.6.3.4 Derived Conditional Distribution of Wind Speed Given Wind Direction.

Continuing with the considerations expressed in Paragraph 2.6.3.3, the conditional probability density function (pdf) for wind speed (r), given a specified value for the wind direction θ, can be expressed as:

$$f(r \mid \theta) = \frac{a^2\, r\, e^{-\frac{1}{2}(a^2 r^2 - br)}}{1 + \sqrt{2\pi}\,\left(\frac{b}{a}\right) e^{\frac{1}{2}\left(\frac{b}{a}\right)^2}\,\Phi\left\{\frac{b}{a}\right\}} \tag{36}$$

where coefficients, a and b and the function $\Phi\left\{\frac{b}{a}\right\}$ are as previously defined in equations 33 and 34.

From equation 36, the mode (most frequent value) of the conditional wind speed given a specified value of the wind direction is the positive solution of the quadratic equation,

$$a^2 r^2 - br - 1 = 0 \tag{37}$$

which is:

$$(\tilde{r} \mid \theta) = \frac{1}{2a}\left[\left(\frac{b}{a}\right) + \sqrt{4 + \left(\frac{b}{a}\right)^2}\right] \tag{38}$$

The locus of the conditional modal values of wind speed when plotted in polar form versus the given wind directions forms an ellipse.

The noncentral moment for equation 36 is expressed as:

$$\mu_n' = \int_o^\infty r^n \, f(r \mid \theta) \, dr \tag{39}$$

Now the first noncentral moment is identical to the first central moment or expected value, E $(r \mid \theta)$. The integration of equation 39 for the first moment is sufficiently simple to yield practical computations, and can be expressed as:

$$E(r \mid \theta) = \frac{\left(\frac{b}{a}\right) + \left[1 + \left(\frac{b}{a}\right)^2\right] \sqrt{2\pi}\, e^{\frac{1}{2}\left(\frac{b}{a}\right)^2} \Phi\left\{\frac{b}{a}\right\}}{a\left[1 + \left(\frac{b}{a}\right) \sqrt{2\pi}\, e^{\frac{1}{2}\left(\frac{b}{a}\right)^2} \Phi\left\{\frac{b}{a}\right\}\right]} \tag{40}$$

Equation 40, then, gives the conditional mean value of the wind speed given a specified value for the wind direction.

The integration of equation 36 for the limits r = 0 to r = r* gives the probability that the conditional wind speed is $\leq$ r* given a value for the wind direction, θ. This conditional probability distribution (PDF) can be written as:

$$Pr\left\{r \leq r^* \mid \theta = \theta_o\right\} = 1 - \left[\frac{e^{-\frac{1}{2} r_s^2 + \sqrt{2\pi}\left(\frac{b}{a}\right)\{1 - \Phi(r_s)\}}}{e^{-\frac{1}{2}\left(\frac{b}{a}\right)^2 + \sqrt{2\pi}\left(\frac{b}{a}\right)\Phi\left\{\frac{b}{a}\right\}}}\right] \tag{41}$$

where: $r_s = \left[a\, r^* - \left(\frac{b}{a}\right)\right]$

By definition, equation 41 is an expression for a "wind rose." Empirical wind rose statistics are often tabulated or graphically illustrated giving the frequency that the wind speed is not exceeded for those wind speed values which lie within assigned class intervals of wind direction. After evaluation of equation 41 for various values of wind speed, r*, and the given wind directions, θ, interpolations can be performed to obtain various percentile values of the conditional wind speed.

For the special case when $\underline{b}$ in equation 33 equals zero (i.e., for $\bar{x} \equiv \bar{y} = 0$), the conditional modal values of wind speeds (equation 38), the conditional mean values of wind speeds (equation 40), and the fixed conditional percentile values of wind speeds (interpolated from evaluations of equation 41), when plotted in polar form versus the given wind directions, produce a family of ellipses.

For the special case when $\bar{x} = \bar{y} = 0$, equation 36 reduces to the following simple case:

$$Pr\left\{r \leq r^* \mid \theta = \theta_o\right\} = 1 - e^{-\frac{a^2 r^{*2}}{2}} \tag{42}$$

Equation 42 has special significance when related to the bivariate normal probability distribution. If r* and θ are measured from the centroid of the probability ellipse, then the probability that $r \leq r^*$ is the same as the given probability ellipse. Further, solving equation 42 for r*, gives:

$$r^* = \frac{1}{2}\sqrt{-2\,ln\,(1-P)} \tag{43}$$

If a probability ellipse P is chosen, equation 42 gives the distance of r along any θ from the centroid of the ellipse to the intercept of the specified probability ellipse. If there is an interest in conditional probability of winds for a given θ relative to the monthly means, equation 43 is applicable. If it is desired to find the magnitude of the wind along any θ relative to the monthly mean to the intercept of a given probability ellipse, equation 43 is also applicable.

2.7 Statistical Parameters for Non-Standard Orthogonal Axes.

The five wind statistical parameters in Appendix A are given with respect to the Standard Meteorological Coordinate System (Figure 2-1). That is, these parameters are for zonal and meridional components. Many range users, however, need wind statistics with respect to orthogonal axes other than west to east and south to north. For example, a user may need wind statistics with respect to a flight azimuth of α degrees from true north measured clockwise. The following sets of equations are used to compute the five parameters for the new coordinate axes rotated α degrees clockwise from true north.

Rotation of the means through α degrees:

$$\bar{X}_\alpha = \bar{X}\,cos\,(90-\alpha) + \bar{Y}\,sin\,(90-\alpha) \tag{44}$$

$$\bar{Y}_\alpha = \bar{Y}\,cos\,(90-\alpha) - \bar{X}\,sin\,(90-\alpha) \tag{45}$$

Rotation of the variances through α degrees:

$$\sigma_{x_\alpha}^2 = \sigma_x^2\,cos^2\,(90-\alpha) + \sigma_y^2\,(90-\alpha) + 2\rho\sigma_x\sigma_y\,cos\,(90-\alpha)\,sin\,(90-\alpha) \tag{46}$$

$$\sigma_{y_\alpha}^2 = \sigma_y^2\,cos^2\,(90-\alpha) + \sigma_x^2\,sin^2\,(90-\alpha) - 2\rho\sigma_X\sigma_y\,cos\,(90-\alpha)\,sin\,(90-\alpha) \tag{47}$$

Rotation of the linear correlation coefficient through α degrees:

$$\rho_\alpha = \frac{cov\,(X,Y)_\alpha}{\alpha_{x_\alpha}\alpha_{y_\alpha}} \tag{48}$$

where cov $(X,Y)_\alpha$ is the rotated covariance:

$$cov\,(X,Y)_\alpha = (X,Y)\,[cos^2\,(90-\alpha) - sin^2\,(90-\alpha)] + cos\,(90-\alpha)\,sin\,(90-\alpha)\,(\sigma_y^2 - \sigma_x^2)$$

and

$$cov\,(X,Y) = \rho\sigma_x\sigma_y$$

By using these rotational equations, the bivariate normal distribution with respect to any desired rotated coordinates can be obtained from sample estimates that have been computed with respect to a specific axis. The marginal distributions after rotation are also normally (univariate) distributed. By using the rotational equations, computational efforts are greatly reduced for applications requiring statistics with respect to several coordinate axes.

Appendix E gives examples of range-specific RRA wind statistics.

Chapter 3

THERMODYNAMICS STATISTICS AND MODELS

3.1 GENERAL DISCUSSION.

One of the objectives in developing the RRA was to describe the thermodynamic characteristics of the atmosphere as completely as possible with as few data tabulations as possible. With that in mind, a set of statistical variables was selected to collectively describe climatological pressure, temperature, density, dew point, virtual temperature, and water vapor pressure. Used together, these variables permit calculation of a large number of derived quantities. Some of these quantities (such as the speed of sound) are discussed in Paragraph 3.7.

The probability distribution of each of the six thermodynamic RRA variables is described by its mean value, its standard deviation, and its skewness. Several of the thermodynamic elements (temperature, pressure, dew point, and density) have probability distributions that are close to a univariate normal distribution; the others do not. The skewness variable gives an estimate of the asymmetrical departures of a probability distribution.

Hydrostatically modeled mean values of pressure and density were calculated (see Appendix D) so that users can determine the departure of the actual climatology of these values from hydrostatic conditions. This was done by hydrostatically integrating the pressure from the lowest RRA data level to the RRA's termination altitude. Table 3-1 lists and explains the primary physical constants used in RRA production. Table 3-2 lists and explains the symbols used in this chapter.

TABLE 3-1. Primary Physical Constants Used in RRA Production.

P_0	Standard atmospheric pressure at sea level (1.013250 X 10^5 Newton/m^2) (2116.22 lb/ft^2)
ρ_0	Standard atmospheric density at sea level (1.2250 kg/m^3) (0.076474 lb/ft^3)
T_0	Standard temperature at sea level (288.15 K) (15.0^{0}C) (59.0^{0}F)
g_0	Standard gravity at sea level at latitude 45^{0}31'33" (9.80665 m/s^2)
s	Sutherland's constant used in calculation of dynamic viscosity (110.4 K)
T_I	Ice-point temperature at P_o (273.15 K)
β	Constant for calculating dynamic viscosity (1.458 x 10^{-6} kg/sec m $K^{\frac{1}{2}}$) (7.3025 x 10^{-7} lb/sec ft $R^{\frac{1}{2}}$)
γ	Ratio of specific heat of air at constant pressure to specific heat of air at constant volume (1.4)
C_D	Mean effective collision diameter of air molecules (3.65 x 10^{-10} m) (1.1975 x 10^{-9} ft)
N_a	Avogadro's constant (6.022169 x 10^{26}/kg mol) (2.73179 x 10^{26}/lb mol)
R^*	Gas constant (8.31432 Joule/mol K)
R'	Gas constant for dry air (2.8704 x 10^2 Joule/kg K)
M	Molecular weight of dry air (28.966 gm/mol)

TABLE 3-2. Symbols Used in Chapter 3.

C_s	Speed of sound
C_d	Collision diameter
E	Vapor pressure
g_ϕ	Gravity at latitude ϕ
H	Geopotential height
H_m	Geopotential height at a mandatory radiosonde data level
H_s	Geopotential height at a significant radiosonde data level
K_t	Coefficient of thermal conductivity
L	Mean free path length
M	Mean molecular weight of air at sea level
$M3q$	Monthly third moment of quantity Q
n	Refractive modulus
N	Refractive index
NA	Avogadro's constant
Nq	Number of values of quantity Q
P	Pressure
P_m	Pressure at a mandatory radiosonde data level
P_s	Pressure at a significant radiosonde data level
P_h	Hydrostatically integrated mean monthly or annual pressure
Q	Any tabulated RRA quantity
R^*	Universal gas constant
R	Specific gas constant of dry air
r, r^*	Parameters used in converting z to h and vice versa
S	Sutherland's constant, used in the calculation of dynamic viscosity
T	Temperature
T_d	Dewpoint
T_v	Virtual temperature
T_{vm}	Virtual temperature at a mandatory radiosonde data level
T_{vs}	Virtual temperature at a significant radiosonde data level
V	Mean air particle speed
	Mean collision frequency
w	Parameter used in the hydrostatic interpolation of pressure and density
Z	Geometric altitude
X	Wavelength
αQ	Skewness of quantity Q
B	Constant used in the equation for viscosity
γ	Ratio of specific heat at constant pressure to specific heat at constant volume
η	Kinematic coefficient of viscosity
μ	Dynamic coefficient of viscosity
ρ	Density
ρh	Mean monthly or annual density derived from Ph
σ	Standard deviation of the quantity Q

3.2 QUALITY CONTROL.

Data limits derived from the following thermodynamic elements were used to screen the RRA database: temperature, pressure, dewpoint (for the 0-30 km portion only), and density. These limits were set to plus and minus six standard deviations from the mean values of each of these quantities; they were then used to screen the thermodynamic portion of the database IAW procedures described in Paragraph 1.5. The database was considered to be error-free if:

(1) Skewness values of pressure and temperature were between -2.5 and 2.5 at all data levels.

(2) Skewness values of density were between -3.5 and 3.5 at data levels between 0 and 30 km.

(3) Skewness values of density were between -3.0 and 3.0 at data levels between 30 and 70 km.

(4) Skewness values of dewpoint were between -2.5 and 2.5 at all data levels with more than 10 data values.

3.3 DATA LIMITATIONS.

Correlation coefficients between thermodynamic quantities and moisture-related quantities were not calculated at discrete altitudes; neither were any of the correlations between altitudes. As a result, valid statistical dispersion models that require relationship between two or more of these quantities at the same altitude or between altitudes cannot be derived. Approximations for the correlation coefficients between pressure, virtual temperature, and density at discrete altitudes, however, may be obtained from the coefficients of variation as developed by Buell (1970). The coefficient of variation is the standard deviation divided by the mean. The mean values and the standard deviations are taken from Appendix B. A model for the profile of monthly and annual mean pressure, virtual temperature, and density is given in Appendix D, and is in excellent agreement with the respective statistical mean values. This agreement results because the physical relationships expressed by the hydrostatic equation and the equation of state were used to derive Appendix D. When only the monthly or annual mean values for pressure, virtual temperature, and density are required, users should consult Appendix D.

3.4 ESTABLISHING DATA SAMPLES AT REQUIRED LEVELS.

This section describes the computational procedures used to establish data samples of the thermodynamic RRA variables at the various data levels. References are cited only when the equation given is one of many available in the literature or when it is stated in an unusual form.

3.4.1 Converting Geopotential Height to Geometric Altitude.

Although rocketsonde observations above 30 km are recorded in terms of geometric altitude, the data can be interpolated directly to the altitude intervals shown in the tables. But radiosonde observations used to obtain tabular values below 30 km are recorded in terms of geopotential height; the conversion to geometric altitude (h to z) is accomplished by calculating a table of geopotential heights that correspond exactly to the geometric altitudes at which the atmospheric elements are tabulated. Radiosonde observations are then interpolated to these geopotential heights. The relationship used to calculate geometric altitude from geopotential height is:

$$H = (r' z) / (r^* + z) \tag{49}$$

where $r' = g r^* / 9.80665$

and $r^* = -2 g_\phi / (\partial g_\phi / \partial z_o)$

g_ϕ is sea level at latitude ϕ corresponding to the proper location (List, 1968).

$$g_\phi = 9.780356 (1 + 5.2885 \times 10^{-3} \sin^2 \phi - 5.9 \times 10^{-6} \sin^2 (2\phi)) \tag{50}$$

$\frac{\partial g_\phi}{\partial z_o}$ is the rate of change of gravity at sea level. This quantity is given by:

$$\frac{\partial g_\phi}{\partial z_o} = -3.085462 \times 10^{-6} \times 2.27 \times 10^{-9} \cos(2\phi) \times 2 \times 10^{-12} \cos(4\phi) \quad (51)$$

Units used for gravity are m/s^2, while the units for $\frac{\partial g_\phi}{\partial z_o}$ are s^{-2}.

The resulting table of values of H obtained by using even increments of 2 in equation 49 is shown in Appendix D. Although the values of H above 30 km were not used in the interpolation of original data, they are included for the convenience of the user.

3.4.2 Calculations from Rawinsonde Observations.

It was necessary to interpolate information from original rawinsonde records to arrive at the geometric altitudes specified as RRA data levels. Elements for which this interpolation was required were temperature, dewpoint, and pressure. The other elements were calculated from the interpolated values at each RRA data level. These "derived" elements were water vapor pressure, density, and virtual temperature.

3.4.2.1 Geopotential Height at Significant Levels.

Two slightly different interpolation procedures were used to obtain data from radiosonde and rocketsonde observations at the levels shown in the tables. The procedure used to interpolate radiosonde observations begins with calculations of virtual temperature at each data level in the sounding. Virtual temperature was computed by:

$$T_v = T / (1. - 0.379\,(e/p)) \quad (52)$$

where T_v and T are in kelvin (K) and e and p are in millibars.

Radiosonde soundings provide pressure, temperature, and dew point data recorded at "mandatory" and "significant" levels. Geopotential height data, however, is only provided for mandatory levels. Heights at the significant levels, therefore, were calculated hydrostatically, using pressure and temperature data from those levels. This procedure allows the use of most significant level data in the calculation of the RRA tables. The equation used for this process was:

$$H_s = Hm + 29.2712617 * \frac{(T_{vs} + T_{vm})}{2} * \ln(P_s/P_m) \quad (53)$$

where subscripts *s* and *m* denote quantities at significant and mandatory levels. This equation was not used if the difference between two adjacent mandatory levels was greater than 200 mb, and all soundings with such data gaps were rejected.

3.4.2.2 Temperature.

Radiosonde temperatures were interpolated logarithmically with respect to pressure using the equation:

$$T = T_U + (T_L - T_U) \frac{\ln p - \ln p_L}{\ln p_U - \ln p_L} \quad (54)$$

where subscripts *U* and *L* indicate values at the nearest data levels in the actual sounding above and below the interpolated level.

3.4.2.3 Pressure.

The pressure values in each radiosonde sounding were interpolated to the RRA data levels using the equation:

$$p = pL\ exp\left(\frac{H_L - H_U}{29.2712617\ (0.5)\ (T_{v_U} + T_{v_L})}\right) \tag{55}$$

where subscript L indicates virtual temperature, geopotential, and pressure values at the data level below and closest to the level at which data were required.

3.4.2.4 Dew Point Temperature.

Dew point values were interpolated logarithmically with respect to pressure using the equation:

$$T_d = T_{dU} + (T_{dL} - T_{dU})\left(\frac{lnp - ln\,p_L}{ln\,p_U - ln\,p_L}\right) \tag{56}$$

Subscripts U and L indicate data at the nearest upper and lower data levels in a sounding.

3.4.2.5 Vapor Pressure.

Water vapor pressure is calculated from interpolated dew point values at RRA data levels using Teten's approximation:

$$e = 6.11\ mb \times 10^{7.5(T_d - 273.15)\ /\ (T_d - 35.86)} \tag{57}$$

3.4.2.6 Density.

Density values derived from radiosonde observations were calculated at RRA data levels using the equation:

$$\rho = 348.36787\ p/T_v \tag{58}$$

3.4.2.7 Virtual Temperature.

Virtual temperature values are calculated at RRA data levels for each sounding using the equation:

$$T_v = T/(1 - 0.379(e/p)) \tag{59}$$

where Tv and T are in K; pressure (p) and vapor pressure (e) are in millibars.

3.4.3 Calculations from Rocketsonde Observations.

Rocketsonde observations used to calculate RRA table values above 30 km were recorded in terms of geometric altitude. For this reason, slightly different calculations were required to convert recorded data values to RRA data levels. Pressure, temperature, and density were interpolated to RRA data levels. Since atmospheric moisture at altitudes above 30 km is considered to be negligible, moisture-related elements (virtual temperature, water vapor pressure, and dewpoint) were not calculated. There was no interpolation across gaps in pressure or temperature data in a sounding larger than 7,000 meters. Data values at RRA levels within such a gap were set to "missing."

3.4.3.1 Temperature.

Rocketsonde temperatures were interpolated linearly with respect to geometric altitude using the equation:

$$T = T_U + (T_L - T_U)\ \frac{Z - Z_L}{Z_U - Z_L} \tag{60}$$

where subscript U indicates values at the nearest data level in the actual sounding above the interpolated level; L indicates values below the interpolated level.

3.4.3.2 Pressure.

Rocketsonde pressure values were interpolated to RRA data levels using the equation:

$$P = P_L \exp\left(-\frac{g_\phi}{R^*}\frac{M\,(Z - Z_L)}{T_v} \cdot W^2\right) \tag{61}$$

where $T_v = \frac{T v_U + T v_L}{2}$ and $W = \frac{r^*}{\left(r^* + Z + \frac{Z - Z_L}{2}\right)}$

3.4.3.3 Density.

Rocketsonde density values were interpolated using the equation:

$$\rho = \rho_L \exp\left(-\frac{g_\phi M}{R^*}\frac{(Z - Z_L)}{T_v} \cdot W^2\right) \tag{62}$$

where W is specified in 3.4.3.2.

3.5 COMPUTING STATISTICS FOR APPENDICES B AND C.

Computing monthly and annual means, standard deviations, and skewness values from data at the RRA data levels was in two steps. First, certain statistical sums were calculated and stored as the soundings in the database were processed. These sums were then used to calculate the monthly and annual statistics given in the RRA tables.

3.5.1 Stored Statistical Sums.

The sums that were calculated were:

$$\Sigma Q,\ \Sigma Q^2,\ \text{and}\ \Sigma Q^3$$

where Q is any one of the quantities given in the thermodynamic part of the RRA.

3.5.2 Calculating Monthly Statistics.

3.5.2.1 Monthly Means.

Mean monthly values of the thermodynamic RRA quantities were calculated using the equation:

$$\overline{Q} = \Sigma Q / N_Q$$

where N_Q is the number of observed values of the quantity Q for a given month.

3.5.2.2 Monthly Standard Deviations.

Monthly standard deviations of the thermodynamic RRA quantities were calculated using the equation:

$$\sigma_Q = \sqrt{\frac{(N_Q \Sigma Q^2) - (\Sigma Q)^2}{N_Q \cdot (N_Q - 1)}} \tag{63}$$

3.5.2.3 Monthly Skewness Values.

Monthly skewness values of wind speed and thermodynamic RRA quantities are calculated using the equation:

$$\sigma_Q = \frac{M 3_Q}{\sigma_Q^3}$$

where $M3_Q$ is the third moment of the quantity Q, σ_Q is its standard deviation, and

$$M_{3Q} = \left[\frac{\Sigma Q^3}{N_Q} - \frac{3\Sigma Q \Sigma Q^2}{N^2_Q} + \frac{2\Sigma Q^3}{N^3_Q} \right] \cdot \frac{N_Q^2}{(N_Q - 1)(N_Q - 2)} \tag{64}$$

3.5.3 Calculating Annual Statistics.

Equations 63 and 64, used to calculate monthly values of standard deviations and skewness values, were also used for the annual statistics.

3.5.3.1 Annual Means.

Annual mean values of the thermodynamic RRA quantities were calculated using the equation:

$$Q_{ANN} = Q_A / N_Q$$

where Q_A is the total of all observed values of Q and N_Q is the total number of observations of Q.

3.5.3.2 Annual Standard Deviations and Skewness Values.

Annual standard deviations of the thermodynamic RRA quantities were calculated using equation 63; annual skewness values were calculated with equation 64. **NOTE**: Both these quantities were previously calculated with monthly statistics due to limitations in computer precision.

3.6 MONTHLY AND ANNUAL MEAN MODEL ATMOSPHERES.

A set of modeled monthly mean and annual mean hydrostatic values of pressure and density was calculated from the lowest RRA data level (0 km, mean sea level) to 30 km, and from 30 km to 70 km. The integration from 0 to 30 km was computed independently of the integration from 30 to 70 km because of the difference in data sources. These hydrostatically modeled mean values (given in Appendix D) are useful as a check on the validity of pressure and density values given in Appendix B. In most cases, the values in Appendices B and D for any given data level are within 1 percent of each other. The hydrostatic pressure values in Appendix D were calculated using the equation:

$$p_1 = p_0 \, exp \left(- \frac{0.034162 \, (H_1 - H_0)}{0.5 \, (T_{v_1} + T_{v_0})} \right) \tag{65}$$

where, $H_1 - H_0$ is in meters and a "0" subscript refers to values at the RRA data level immediately below the level being checked. p_0 at the lowest data level is set equal to the RRA mean pressure; p_1, calculated for the next highest data level, is taken as p_0 for the level above that. This process is repeated for all the other RRA data levels. The hydrostatic density corresponding to hydrostatic pressures is calculated from these pressures and from RRA virtual temperature values using the formula:

$$\rho_H = 348.36786 \, P_H / T_v \tag{66}$$

where ρ_H and P_H are the hydrostatic density and pressure shown in Appendix D.

3.7 THERMODYNAMIC QUANTITIES DERIVABLE FROM TABLES.

Several other quantities can be calculated from the statistics given in Appendices B and D. The equations in this section can be used to calculate approximate mean values of these quantities at each RRA data level. It is not possible, however, to infer or derive any information concerning standard deviation or skewness values of these quantities from the data in Appendices B and C.

3.7.1 Mean Air Particle Speed.

The mean air particle speed, "V", is the arithmetic average of the speeds of all air particles in the volume element being considered. For a valid average to occur, there must be a sufficient number of particles involved to represent mean conditions. The equation for "V" for dry air is:

$$V = \sqrt{\frac{8}{\pi} \cdot \frac{R^* T}{M}} \tag{67}$$

A computational form for dry air, using tabulated values, is:

$$V = \sqrt{7.3094 \times 10^2 \times T} \quad \text{(m/s)} \tag{68}$$

where T is the temperature in kelvin (K) from Appendix B. Equation 67, when corrected for moist air, becomes:

$$V = \sqrt{\frac{8}{\pi} \cdot R' T_v} \tag{69}$$

The computational form for moist air is:

$$V = \sqrt{7.3094 \cdot 10^2 \cdot T_v} \quad \text{(m/s)} \tag{70}$$

where T_v is the virtual temperature in kelvin (K) from Appendix C.

3.7.2 Mean Free Path.

The mean free path, "L" is the mean value of the distance traveled by each neutral air particle, in a selected air parcel, between successive collisions with other particles in that parcel. A meaningful average requires that the selected parcel be large enough to contain a substantial number of particles. The equation for L is given by:

$$L = \left(\frac{\sqrt{2}}{2\pi}\right)\left(\frac{R^* T}{N_a C_d^{\,2} P}\right) \tag{71}$$

where C_d is the effective collision diameter of the mean air molecules. The 1976 standard atmosphere value of 3.65×10^{-10} is valid for the range of altitudes in the RRA. A computational form for moist air, using tabulated values, is:

$$L = 2.335 \times 10^{-7} \frac{T}{P} \text{ (meters)} \tag{72}$$

where T is the temperature in K and P is the pressure in mb, both from Appendix B. A form of equation 71 to correct L for moist air is:

$$L = \left(\frac{\sqrt{2}}{2\pi}\right) \frac{R' M T_v}{N_a C_d^2} \tag{73}$$

The computational form for moist air is:

$$L = 2.3325 \times 10^{-7} \frac{T_v}{P} \text{ (meters)} \tag{74}$$

where T_v is the virtual temperature in K from Appendix C and P is the pressure in mb from Appendix B.

3.7.3 Mean Collision Frequency.

The mean collision frequency (V_c) is considered to be the average speed of air particles contained in an air parcel divided by the mean free path of the particles inside that parcel. Computationally, this is equivalent to:

$$V_c = \frac{V}{L} \ (sec^{-1}) \tag{75}$$

To determine V_c for dry air, use V and L from equations 68 and 72. To determine V_c for moist air, use V and L from equations 70 and 74.

3.7.4 Speed of Sound.

The expression for the speed of sound (C_s) in dry air, in (m/s) is:

$$C_s = \sqrt{\frac{\gamma R^* T}{M}} \tag{76}$$

To compute C_s for dry air from tabulated values, use:

$$C_s = \sqrt{4.0185 \times 10^2 \times T} \ \text{(m/s)} \tag{77}$$

where T is the temperature K from Appendix B. One form for the speed of sound in moist air is:

$$C_s \approx \sqrt{\gamma R' T_v} \tag{78}$$

where T_v is the virtual temperature from Appendix C. A computational form for moist air is:

$$C_s \approx \sqrt{4.0185 \times 10^2 \ T_v} \ \text{(m/s)} \tag{79}$$

3.7.5 Coefficient of Dynamic Viscosity.

The coefficient of dynamic viscosity, μ, is defined as a coefficient of internal friction developed where gas regions move adjacent to each other at different velocities. The following expression is taken from the U.S. Standard Atmosphere (1976):

$$\mu = \frac{\beta \bullet T^{3/2}}{T + S} \tag{80}$$

The computational form is:

$$\mu = \frac{(1.458 \times 10^{-6}) \ T^{3/2}}{T + 110.4} \ , \left(\frac{kg}{s \bullet m}\right) \tag{81}$$

where T is temperature K from Appendix B.

3.7.6 Kinematic Coefficient of Viscosity.

The kinematic coefficient of viscosity, designated as η, is defined as the ratio of the dynamic coefficient of viscosity of a gas to its density, or:

$$\eta = \mu/\rho \tag{82}$$

The computational form is:

$$\eta = 1.0 \times 10^3 \ \mu/\rho \quad , \quad (m^2/s) \tag{83}$$

where μ is the dynamic coefficient of viscosity from equation (81) and ρ is the density in g m^{-3} from Appendix B.

3.7.7 Coefficient of Thermal Conductivity.

The empirical expression used for the coefficient of thermal conductivity (K_t) is given in the 1976 Standard Atmosphere as:

$$K_t = \frac{2.65019 \times 10^{-3} \cdot T^{3/2}}{T + 245.4 \times 10^{-(12/T)}} \ , \ \text{(watts/m-deg K)} \tag{84}$$

where T is temperature K.

3.7.8 Refractive Modulus and Refractive Index.

The refractive modulus or refractivity (Selby and McClatchey, 1975; Smith and Weintraub, 1953), is expressed as N, where:

$$N = (n - 1) \cdot 10^6 \tag{85}$$

and n is the refractive index.

For microwave frequencies below approximately 30 GHz (equivalent to wavelengths above 1 cm), N, the refractive modulus, is given by the empirical equation:

$$N = 77.6 \frac{P}{T_d} + 3.73 \times 10^5 \frac{e}{T^2} \ \textit{(dimensionless)} \tag{86}$$

where E and P are in millibars and T and T_d are in K.

The following expression is valid for visible and infrared wavelengths shorter than approximately 30 μm (0.03 mm):

$$N = 77.6 \frac{P}{T} + 0.584 \frac{P}{T\nu} \ \text{(dimensionless)} \tag{87}$$

where λ is the wavelength in microns and T is in degrees K.

The expression for N for the wavelength from 0.03 mm to 1 cm is an extremely complex function of wavelength.

Chapter 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS.

This document satisfies the technical objectives established for the Range Reference Atmosphere committee by the Range Commanders Council Meteorology Group. Upper-air statistics and models for wind and thermodynamic quantities for the range specified have been derived through consistent and uniform methods that will be used in similar publications for other ranges. This new Range Reference Atmosphere (RRA) series is an improvement over previously published RRAs for several reasons: for one, the upper-air database is much larger and much better. For another, more advanced statistical techniques have been developed.

In this series, a statistical measure of central tendency (mean values) and a measure of dispersion (standard deviation with respect to mean values) for monthly and annual reference periods have been consistently tabulated for all variables, using databases that have been carefully edited and quality controlled. Further, a statistical measure for symmetry (skewness coefficient which involves the third statistical moment) has been tabulated for all variables except the zonal and meridional wind components. But even with these improvements, RRA users must recognize certain limitations of the statistical tabulations; these limitations are described here to discourage misuse of the RRA.

- The wind profile structure with respect to altitude cannot be modeled from RRA statistics because inter-level and cross-level correlations were not computed.

- The profile structure with respect to altitude for any of the thermodynamic variables or any quantities derivable from thermodynamic variables cannot be modeled because the prerequisite correlations were not computed. However, the profile of monthly and annual means for pressure, virtual temperature, and density given in Appendix D are in agreement with the hydrostatic equation and the equation of state.

Although more extensive statistical tabulations are currently impractical, many adaptations of current statistics for specific engineering and scientific applications are envisioned as insight is gained through RRA use.

4.2. RECOMMENDATIONS.

The agency responsible for RRA preparation recommends that the wind and thermodynamic statistical tabulations and models in this RRA be used with confidence as a standard reference to the atmosphere over the location for which it has been prepared. It is further recommended that RRA users consult their Staff Meteorologist for assistance before attempting to apply RRA data to specific engineering projects.

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ACRONYMS, INITIALISMS, AND ABBREVIATIONS (ACRINABs)

AD	Armament Division
AFFTC	Air Force Flight Test Center
AFSC	Air Force Systems Command
AFSCF	Air Force Satellite Control Facility
AFTFWC	Air Force Tactical Fighter Weapons Center
AWS	Air Weather Service
BMD	Ballistic Missile Division
CSTC	Consolidated Space Test Center
DOD	Department of Defense
DOE	Department of Energy
DOE/NTS	DOE/Nevada Test Site
DPG	Dugway Proving Ground
EPG	Electronic Proving Ground
ESMC	Eastern Space and Missile Center
ETR	Eastern Test Range
GL	Geophysics Laboratory
KMR	Kwajalein Missile Range
NASA	National Aeronautics and Space Administration
NASA/MSFC	NASA/Marshall Space Flight Center
NASA/WFC	NASA/Wallops Flight Center
NATC	Naval Air Test Center
NOAA	National Oceanic and Atmospheric Administration
NWC	Naval Weapons Center
PMTC	Pacific Missile Test Center
SAMTO	Space and Missile Test Organization
TFWC	Tactical Fighter Weapons Center
TSCF	Targeting Systems Characterization Facility
USA/DTA	U.S. Army/Desert Test Center
USAECOM	U.S. Army Electronics Command
USAFETAC	USAF Environmental Technical Applications Center
USAKA	U.S. Army Kwajalein Atoll
UTTR	Utah Test and Training Range
WSMC	Western Space and Missile Center
WSMR	White Sands Missile Range
WTR	Western Test Range
YPG	Yuma Proving Ground
6585TG	6585th Test Group

APPENDIX A

Fairbanks Wind Statistics Tables

Table A-1 through Table A-13 give statistical wind data (monthly and annual) for Fairbanks. Data was produced as described in Chapter 2.

TABLE A-1. January Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	-0.36	1.47	0.3017	-0.76	1.64	1.66	1.53	1.48	796.
1.000	-3.02	7.32	-0.0306	2.26	4.12	7.71	4.75	0.82	853.
2.000	0.38	8.18	0.1205	2.71	6.12	9.01	5.24	0.91	853.
3.000	2.59	8.64	0.1679	2.88	7.76	10.49	5.97	0.97	853.
4.000	4.16	9.55	0.0762	2.96	8.98	12.16	6.79	0.87	853.
5.000	5.59	11.08	0.0490	3.23	10.48	14.31	8.33	0.90	851.
6.000	7.19	12.51	0.0149	3.58	11.99	16.49	9.63	0.79	848.
7.000	8.82	14.05	-0.0149	3.97	13.68	18.73	11.26	0.90	843.
8.000	10.35	15.26	-0.0315	4.25	14.89	20.60	12.45	0.94	835.
9.000	11.65	14.86	-0.0256	4.45	15.08	21.07	12.64	1.02	829.
10.000	12.45	12.96	-0.0502	4.14	13.80	19.90	11.59	1.00	825.
11.000	12.84	10.40	-0.1238	3.52	11.73	18.22	9.54	0.81	822.
12.000	13.39	9.05	-0.1781	3.12	10.59	17.68	8.39	0.57	819.
13.000	14.49	8.83	-0.1736	2.71	9.89	18.13	8.01	0.43	814.
14.000	15.73	9.03	-0.1714	2.09	9.85	18.98	8.37	0.47	809.
15.000	16.93	9.42	-0.1755	1.65	10.02	20.00	8.85	0.45	803.
16.000	18.51	9.32	-0.1508	1.05	10.18	21.15	9.31	0.36	707.
17.000	19.83	10.04	-0.1303	0.28	10.46	22.40	10.08	0.30	684.
18.000	21.00	10.83	-0.1261	-0.48	10.90	23.57	11.02	0.26	679.
19.000	22.15	11.62	-0.1197	-1.40	11.17	24.69	11.94	0.27	668.
20.000	23.12	12.42	-0.1142	-2.50	11.72	25.83	12.84	0.22	660.
21.000	24.16	13.28	-0.1174	-3.65	12.27	27.08	13.81	0.28	642.
22.000	24.93	14.11	-0.1036	-4.57	12.70	28.14	14.52	0.25	622.
23.000	25.73	15.21	-0.0649	-5.55	13.34	29.31	15.59	0.27	605.
24.000	26.16	16.11	-0.1023	-6.77	13.79	30.17	16.43	0.32	563.
25.000	26.33	16.79	-0.1025	-7.68	14.35	30.90	16.88	0.32	512.
26.000	26.15	17.81	-0.0630	-8.42	14.78	31.44	17.35	0.39	473.
27.000	27.23	19.13	-0.0838	-9.82	15.84	33.44	18.34	0.46	417.
28.000	27.06	19.59	-0.0772	-10.70	16.39	34.15	18.22	0.44	360.
29.000	27.39	20.25	-0.0632	-11.96	17.36	35.44	18.63	0.55	294.
30.000	27.43	21.34	-0.0424	-12.26	17.37	35.97	19.08	0.67	224.

TABLE A-2. February Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	-0.32	1.40	0.3119	-0.61	1.78	1.77	1.51	0.91	735.
1.000	-3.16	6.24	0.0658	1.43	3.81	6.96	3.97	0.78	781.
2.000	-0.81	7.80	0.3537	2.17	5.82	8.66	5.00	0.95	781.
3.000	1.43	8.34	0.3676	2.54	7.50	10.23	5.44	0.68	781.
4.000	2.87	9.11	0.3437	2.55	9.23	12.01	6.20	0.72	780.
5.000	4.04	10.43	0.2971	2.80	11.28	14.14	7.75	0.97	779.
6.000	5.23	12.15	0.2767	3.10	13.41	16.56	9.49	1.09	771.
7.000	6.63	13.75	0.2739	3.04	15.57	18.94	11.21	0.99	764.
8.000	7.71	14.59	0.2381	3.04	17.14	20.47	12.47	0.96	763.
9.000	8.84	13.75	0.2073	2.87	17.05	20.26	12.45	1.04	759.
10.000	9.95	12.36	0.2066	2.70	15.34	19.20	11.20	1.25	755.
11.000	10.72	10.57	0.1833	2.22	13.09	17.83	9.21	1.29	755
12.000	11.25	8.87	0.1467	1.96	11.84	16.82	7.45	0.79	750.
13.000	12.06	8.61	0.0960	1.65	11.08	17.08	7.30	0.88	746.
14.000	12.90	8.75	0.0375	1.36	10.88	17.50	7.52	0.72	744.
15.000	13.59	9.07	0.0066	0.95	10.73	17.85	8.00	0.86	739.
16.000	13.94	9.41	0.0152	0.36	10.78	18.02	8.62	0.88	655.
17.000	14.48	10.11	-0.0177	-0.07	10.73	18.34	9.51	1.01	651.
18.000	15.08	10.76	-0.0475	-0.54	10.78	18.73	10.43	1.03	649.
19.000	15.49	11.69	-0.0686	-1.11	10.77	19.10	11.35	1.08	645.
20.000	15.64	12.43	-0.0979	-1.78	10.91	19.29	12.21	1.11	638.
21.000	15.96	13.29	-0.0955	-2.46	11.37	19.81	13.19	1.15	629.
22.000	15.90	13.55	-0.1205	-3.03	11.48	19.96	13.37	1.06	614.
23.000	16.17	14.34	-0.1257	-3.65	11.77	20.48	14.11	1.05	595.
24.000	16.41	15.00	-0.0833	-4.24	12.09	21.04	14.69	0.98	579.
25.000	16.18	15.36	-0.0784	-4.86	12.33	21.17	14.99	0.96	551.
26.000	15.88	16.15	-0.0886	-5.58	12.46	21.39	15.55	0.94	517.
27.000	15.57	17.01	-0.0996	-6.40	12.86	21.96	15.99	1.01	463.
28.000	15.13	17.66	-0.0686	-7.06	13.59	22.79	15.98	0.95	410.
29.000	15.02	17.75	-0.0990	-7.68	14.16	23.54	15.66	1.01	330.
30.000	14.69	17.81	-0.0650	-8.52	15.20	24.50	15.33	1.06	261.

TABLE A-3. March Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	-0.35	1.91	0.3928	-0.77	2.37	2.57	1.83	0.89	819.
1.000	-1.57	5.93	0.0840	1.60	3.03	6.04	3.59	0.85	857.
2.000	0.76	6.72	0.2378	2.79	4.16	7.32	4.16	0.92	857.
3.000	2.58	6.57	0.2581	3.33	5.23	8.23	4.52	0.69	857.
4.000	4.17	7.21	0.2117	3.59	6.31	9.65	5.38	0.81	855.
5.000	5.58	8.48	0.1132	3.75	7.71	11.55	6.56	0.82	855.
6.000	7.03	10.33	0.0753	3.93	9.17	13.70	8.23	0.87	851.
7.000	8.35	12.06	0.0414	4.05	10.56	15.81	9.64	0.89	845.
8.000	9.41	13.03	0.0423	4.14	11.20	16.94	10.68	1.09	837.
9.000	10.38	12.77	0.0583	3.85	10.93	16.88	10.97	1.40	834.
10.000	10.30	11.14	0.0529	3.23	9.27	15.21	9.75	1.70	832.
11.000	10.08	9.41	-0.0266	2.65	7.74	13.81	8.14	1.43	829.
12.000	9.77	8.52	-0.0841	2.31	6.91	12.97	7.26	1.07	827.
13.000	9.80	8.25	-0.1643	2.06	6.71	12.73	7.16	0.94	824.
14.000	9.57	8.47	-0.2203	1.71	6.57	12.48	7.32	1.03	818.
15.000	9.46	8.54	-0.2614	1.39	6.51	12.29	7.46	1.02	813.
16.000	9.30	8.78	-0.2899	1.17	6.64	12.21	7.74	1.04	778
17.000	8.95	8.78	-0.3278	0.83	6.64	11.81	7.90	1.19	768.
18.000	8.51	8.90	-0.3545	0.41	6.67	11.41	8.13	1.21	767.
19.000	8.04	8.95	-0.3813	-0.01	6.65	10.96	8.29	1.31	756.
20.000	7.50	9.19	-0.3792	-0.38	6.70	10.62	8.53	1.32	751.
21.000	6.98	9.31	-0.3516	-0.61	6.84	10.45	8.56	1.33	747.
22.000	6.48	9.57	-0.3667	-1.15	6.83	10.36	8.61	1.41	738.
23.000	5.78	9.89	-0.3601	-1.65	6.68	10.28	8.53	1.51	728.
24.000	5.23	10.21	-0.3418	-2.16	6.83	10.50	8.53	1.53	717.
25.000	4.64	10.69	-0.3191	-2.48	7.07	10.74	8.74	1.71	689.
26.000	4.11	11.18	-0.3185	-2.74	7.37	11.12	8.93	1.72	662.
27.000	3.16	11.26	-0.2637	-3.00	7.63	11.29	8.74	1.57	599.
28.000	2.59	12.00	-0.2848	-3.44	8.16	11.97	9.26	1.79	542.
29.000	1.50	12.08	-0.2256	-3.78	8.50	12.42	8.96	1.66	449.
30.000	1.06	12.67	-0.2192	-4.12	9.04	13.21	9.26	1.66	364.

TABLE A-4. April Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	-0.07	2.42	0.1974	-0.47	2.72	3.19	1.81	0.97	798.
1.000	-0.10	5.05	0.0826	1.19	2.96	5.03	3.21	1.25	824.
2.000	1.38	5.47	0.2319	3.09	3.96	6.44	3.93	1.12	824.
3.000	2.43	5.94	0.1619	4.05	5.00	7.89	4.51	0.92	824.
4.000	3.66	7.07	0.0866	4.73	6.37	9.72	5.63	0.98	824.
5.000	4.54	8.49	0.0337	5.28	7.97	11.71	6.84	0.98	824.
6.000	5.73	10.53	0.0251	5.64	9.93	14.00	8.82	1.19	822.
7.000	7.00	12.64	0.0174	5.98	11.99	16.41	10.88	1.30	819.
8.000	8.07	14.18	0.0377	6.15	13.37	18.00	12.60	1.39	816.
9.000	8.90	14.42	0.0280	6.02	13.39	17.97	13.40	1.54	813.
10.000	8.96	13.29	0.0090	5.49	11.96	16.23	12.91	1.71	810.
11.000	8.10	10.95	-0.0114	4.80	9.63	13.84	10.47	1.75	810.
12.000	7.01	8.63	-0.0562	4.26	7.87	11.97	7.77	1.39	809.
13.000	6.19	7.22	-0.0800	4.03	7.05	10.74	6.40	1.13	807.
14.000	5.65	6.48	-0.0836	3.78	6.57	9.87	5.81	1.24	804.
15.000	5.04	5.85	-0.1421	3.43	6.22	9.04	5.33	1.06	801.
16.000	4.34	5.25	-0.1752	3.15	5.77	8.13	4.84	1.15	770.
17.000	3.57	4.64	-0.2056	2.85	5.26	7.22	4.23	1.42	757.
18.000	2.81	4.29	-0.2075	2.56	4.92	6.33	3.67	1.18	757.
19.000	2.20	4.09	-0.1721	2.29	4.50	5.70	3.34	1.28	749.
20.000	1.39	3.98	-0.1588	2.03	4.21	5.15	2.95	1.39	748.
21.000	0.74	4.01	-0.1474	1.70	4.01	4.80	2.83	1.69	733.
22.000	0.03	4.09	-0.1220	1.35	3.77	4.63	2.75	1.98	724.
23.000	-0.72	4.25	-0.0707	0.97	3.75	4.71	2.84	2.09	718.
24.000	-1.37	4.50	-0.0374	0.62	3.65	4.91	3.02	1.97	690.
25.000	-2.18	4.86	-0.0806	0.58	3.59	5.44	3.30	2.20	664.
26.000	-2.79	5.34	-0.0795	0.35	3.73	6.04	3.72	1.95	633.
27.000	-3.18	5.74	-0.0724	0.37	3.74	6.41	3.82	1.36	577.
28.000	-3.59	6.27	-0.0813	0.19	3.85	6.95	4.33	1.34	520.
29.000	-4.13	6.76	-0.0228	-0.01	3.86	7.39	4.77	1.26	431.
30.000	-4.71	7.22	-0.0818	0.03	4.14	7.89	5.40	1.16	336.

TABLE A-5. May Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	0.10	2.71	0.1878	-0.67	2.94	3.61	1.84	0.71	800.
1.000	-0.01	4.69	0.1345	0.93	2.91	4.68	3.06	1.11	831.
2.000	0.21	4.58	0.1524	1.98	3.58	5.30	3.12	0.96	830.
3.000	0.24	5.33	0.1079	2.93	4.20	6.35	3.62	1.01	830.
4.000	0.23	5.80	-0.0242	3.55	4.79	7.19	4.02	0.93	829.
5.000	0.32	6.75	-0.0724	3.94	5.82	8.46	4.83	1.20	828.
6.000	0.37	8.11	-0.0903	4.21	6.96	9.95	5.74	1.27	826.
7.000	0.59	9.47	-0.1049	4.57	8.52	11.69	6.59	0.97	816.
8.000	0.89	10.73	-0.0958	4.72	9.92	13.34	7.64	1.21	812.
9.000	1.37	11.38	-0.1067	4.93	10.55	13.98	8.45	1.23	809.
10.000	1.69	10.39	-0.1163	4.76	9.47	12.47	7.92	1.26	804.
11.000	1.65	8.32	-0.1724	4.46	7.52	10.15	6.37	1.44	798.
12.000	1.46	6.69	-0.2321	4.15	5.86	8.38	4.75	1.30	793.
13.000	1.29	5.73	-0.2657	3.84	4.96	7.34	3.95	1.16	792.
14.000	1.05	4.98	-0.2474	3.51	4.34	6.56	3.49	0.86	789.
15.000	0.81	4.35	-0.2562	3.30	3.80	5.84	3.11	0.86	788.
16.000	0.49	3.76	-0.2424	3.08	3.50	5.30	2.73	0.63	781.
17.000	0.05	3.36	-0.1968	2.94	3.19	4.90	2.46	0.69	744.
18.000	-0.38	2.98	-0.1417	2.68	2.97	4.47	2.24	0.74	744.
19.000	-0.89	2.68	-0.0877	2.50	2.76	4.17	2.11	0.52	731.
20.000	-1.47	2.62	-0.0929	2.18	2.56	4.02	2.04	0.65	731.
21.000	-1.98	2.60	-0.1327	1.94	2.35	3.95	2.07	0.72	718.
22.000	-2.67	2.49	-0.0592	1.69	2.22	4.11	2.04	0.44	707.
23.000	-3.34	2.53	0.0201	1.38	2.17	4.44	2.12	0.34	698.
24.000	-3.95	2.68	-0.0034	1.10	2.13	4.82	2.29	0.69	678.
25.000	-4.49	2.81	-0.0473	0.85	2.20	5.26	2.44	0.58	655.
26.000	-5.00	2.98	-0.0718	0.60	2.24	5.69	2.63	0.55	634.
27.000	-5.46	3.32	-0.1504	0.53	2.34	6.15	2.96	0.70	591.
28.000	-5.94	3.48	-0.2002	0.52	2.53	6.63	3.17	0.84	536.
29.000	-6.23	3.59	-0.0800	0.35	2.58	6.99	3.11	0.66	476.
30.000	-6.49	3.93	-0.1270	0.27	2.52	7.28	3.32	0.71	411.

TABLE A-6. June Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	0.99	2.76	0.3407	0.16	2.75	3.50	1.98	1.05	786.
1.000	1.97	4.80	0.2102	0.58	2.96	5.06	3.22	1.06	821.
2.000	1.65	5.32	0.1265	1.20	3.95	5.95	3.56	1.12	820.
3.000	1.23	5.90	0.0597	1.87	4.67	6.78	3.94	0.92	819.
4.000	1.02	6.38	0.0211	2.17	5.07	7.30	4.33	1.01	818.
5.000	0.91	7.26	-0.0138	2.43	6.01	8.39	5.01	1.21	818.
6.000	0.76	8.39	-0.0323	2.70	7.19	9.77	5.86	1.33	815.
7.000	0.73	9.75	-0.0517	2.94	8.42	11.36	6.78	1.20	803.
8.000	0.76	11.20	-0.0546	3.17	9.77	13.07	7.77	1.25	791.
9.000	1.08	12.56	-0.0705	3.38	11.14	14.75	8.75	1.24	787.
10.000	1.61	12.31	-0.1235	3.19	10.88	14.21	8.97	1.47	785.
11.000	1.93	10.35	-0.1259	2.81	8.95	11.59	8.03	1.68	781.
12.000	1.55	7.84	-0.1194	2.63	6.55	8.83	5.97	1.77	781.
13.000	0.98	6.16	-0.1632	2.33	5.02	7.17	4.24	1.42	779.
14.000	0.58	5.11	-0.2093	2.10	4.17	6.04	3.43	0.98	779.
15.000	0.25	4.34	-0.2531	1.80	3.49	5.15	2.79	0.71	777.
16.000	-0.27	3.66	-0.3018	1.66	3.10	4.47	2.41	0.64	773.
17.000	-0.75	3.23	-0.2908	1.59	2.81	4.05	2.12	0.51	721.
18.000	-1.30	2.79	-0.2290	1.47	2.51	3.71	2.03	0.81	721.
19.000	-1.91	2.39	-0.1464	1.32	2.28	3.57	1.89	0.44	710.
20.000	-2.74	2.24	-0.1009	1.12	2.09	3.83	1.87	0.39	710.
21.000	-3.54	2.15	-0.0731	0.98	1.94	4.29	1.86	0.35	698.
22.000	-4.44	2.13	-0.0828	0.90	1.87	4.95	1.71	0.21	694.
23.000	-5.27	1.91	0.0093	0.67	1.76	5.63	1.65	0.04	683.
24.000	-6.03	2.02	0.2019	0.40	1.76	6.33	1.79	0.04	670.
25.000	-6.77	1.95	0.1907	0.34	1.71	7.03	1.81	0.16	643.
26.000	-7.47	1.90	0.1415	0.44	1.70	7.70	1.77	0.03	618.
27.000	-8.20	2.14	0.1117	0.53	1.84	8.45	2.04	0.30	589.
28.000	-8.70	2.10	0.1982	0.55	1.90	8.92	1.87	0.28	538.
29.000	-9.04	1.99	0.1606	0.46	1.98	9.29	1.89	0.31	472.
30.000	-9.55	2.04	0.2415	0.27	1.98	9.78	1.95	0.19	410.

TABLE A-7. July Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	1.04	2.42	0.4024	0.36	2.53	3.24	1.72	0.89	806.
1.000	2.64	4.88	0.2658	0.78	2.63	5.16	3.42	1.32	842.
2.000	2.63	5.63	0.2140	1.59	3.68	6.25	3.95	1.26	842.
3.000	2.63	6.43	0.1112	2.06	4.43	7.27	4.39	1.10	842.
4.000	2.63	6.93	0.0981	2.28	4.88	7.88	4.67	0.99	841.
5.000	2.72	7.54	0.0709	2.45	5.94	8.86	5.19	0.92	841.
6.000	2.83	8.44	0.0168	2.54	6.98	10.08	5.73	0.80	836.
7.000	3.09	9.41	0.0063	2.61	8.09	11.37	6.39	0.85	834.
8.000	3.30	10.77	-0.0099	2.63	9.37	12.97	7.30	0.81	825.
9.000	3.63	12.30	-0.0030	2.56	10.83	14.70	8.49	0.78	825.
10.000	3.70	13.03	-0.0010	2.29	11.48	15.41	9.09	0.87	821.
11.000	3.56	11.99	-0.0075	1.88	10.34	13.82	8.70	1.06	816.
12.000	3.04	8.83	-0.0795	1.45	7.63	10.22	6.55	1.10	814.
13.000	2.52	6.99	-0.0651	1.36	5.81	8.19	4.87	1.17	812.
14.000	2.06	5.91	-0.0722	1.25	4.63	6.82	3.95	1.24	806.
15.000	1.56	4.94	-0.0347	1.15	4.02	5.80	3.25	1.19	803.
16.000	0.93	4.26	-0.0132	1.01	3.40	4.93	2.69	1.08	800.
17.000	0.45	3.79	-0.0248	0.94	2.94	4.36	2.25	0.74	738.
18.000	-0.21	3.31	-0.0235	0.83	2.61	3.84	1.93	0.53	738.
19.000	-1.01	2.96	-0.0353	0.68	2.33	3.51	1.84	0.66	725.
20.000	-1.87	2.76	0.0215	0.54	2.21	3.49	2.02	0.72	723.
21.000	-2.66	2.64	0.0622	0.39	2.07	3.72	2.16	0.71	718.
22.000	-3.51	2.38	0.0438	0.28	1.83	4.13	2.08	0.41	702.
23.000	-4.34	2.13	0.0269	0.14	1.72	4.73	2.00	0.13	693.
24.000	-4.99	2.00	0.0566	0.01	1.73	5.31	1.91	0.03	689.
25.000	-5.76	1.95	0.0550	-0.16	1.72	6.03	1.90	0.13	670.
26.000	-6.45	1.92	0.1163	-0.17	1.67	6.69	1.85	0.00	656.
27.000	-7.08	2.22	0.0951	-0.01	1.92	7.35	2.15	0.18	637.
28.000	-7.48	2.13	0.0830	0.10	1.78	7.71	2.07	0.15	584.
29.000	-7.90	2.20	0.1717	0.11	1.88	8.15	2.07	0.14	524.
30.000	-8.36	2.33	0.2226	0.16	1.94	8.60	2.24	-0.10	461.

TABLE A-8. August Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	0.54	2.44	0.3733	0.19	2.39	2.94	1.82	1.05	821.
1.000	2.51	5.27	0.2149	1.23	2.92	5.55	3.63	1.27	850.
2.000	3.29	5.81	0.1907	2.10	4.22	7.04	4.15	1.04	850.
3.000	3.67	6.32	0.1106	2.37	5.16	8.14	4.39	0.76	850.
4.000	3.99	6.91	0.0138	2.40	6.07	9.05	4.93	0.81	850.
5.000	4.45	7.74	-0.0689	2.41	7.16	10.24	5.64	0.81	850.
6.000	5.01	8.59	-0.1204	2.38	8.47	11.66	6.34	0.76	844.
7.000	5.52	9.71	-0.1077	2.28	10.00	13.29	7.30	0.76	843.
8.000	6.17	11.09	-0.1137	2.13	11.84	15.25	8.54	0.81	837.
9.000	6.88	12.60	-0.1147	1.93	13.63	17.26	9.86	0.89	834.
10.000	7.84	13.46	-0.1192	1.30	14.62	18.26	11.15	1.01	828.
11.000	8.25	12.48	-0.1145	0.83	13.28	16.96	10.63	1.06	821.
12.000	7.97	10.08	-0.1382	0.55	10.77	14.29	8.77	1.14	820.
13.000	7.34	8.03	-0.1353	0.36	8.72	12.09	6.93	1.02	817.
14.000	6.59	6.51	-0.1239	0.26	7.30	10.33	5.70	0.98	815.
15.000	5.87	5.39	-0.0819	0.22	6.14	8.85	4.78	1.03	810.
16.000	5.02	4.47	-0.0462	0.22	5.14	7.47	3.99	1.00	807.
17.000	4.36	3.93	-0.0079	0.25	4.41	6.49	3.30	0.74	736.
18.000	3.57	3.43	0.0060	0.17	3.77	5.49	2.78	0.75	736.
19.000	2.77	3.16	0.0600	0.12	3.29	4.69	2.41	0.64	724.
20.000	1.98	2.95	0.0631	-0.01	2.89	4.01	2.07	0.61	720.
21.000	1.20	2.82	0.0979	-0.14	2.63	3.50	1.91	0.72	717.
22.000	0.56	2.80	0.1220	-0.22	2.41	3.21	1.75	0.79	710.
23.000	-0.04	2.83	0.1334	-0.29	2.14	3.10	1.75	1.04	696.
24.000	-0.68	2.93	0.1305	-0.27	2.03	3.07	1.70	0.87	682.
25.000	-1.12	2.78	0.1627	-0.24	1.88	3.09	1.64	0.52	656.
26.000	-1.54	2.93	0.1506	-0.21	1.82	3.33	1.79	0.51	643.
27.000	-1.80	3.04	0.0823	-0.19	1.84	3.52	1.87	0.48	611.
28.000	-2.07	3.23	0.1180	-0.08	1.96	3.81	2.01	0.51	572.
29.000	-2.34	3.36	0.1047	0.12	2.07	4.09	2.07	0.11	516.
30.000	-2.53	3.41	0.0735	0.14	2.36	4.24	2.08	0.27	451.

TABLE A-9. September Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	-0.20	2.46	0.3672	-0.38	2.32	2.86	1.85	1.12	775.
1.000	0.32	5.63	0.0988	1.84	3.27	5.74	3.60	1.16	813.
2.000	1.86	5.91	0.1743	3.35	4.51	7.26	4.16	0.86	813.
3.000	2.89	6.20	0.2089	3.80	5.17	8.12	4.69	0.88	813.
4.000	3.78	6.69	0.1726	4.19	5.74	9.06	5.23	0.91	813.
5.000	4.58	7.58	0.1604	4.66	7.02	10.49	6.28	0.94	813.
6.000	5.18	8.96	0.1586	5.22	8.72	12.34	7.61	1.00	812.
7.000	5.83	10.56	0.1284	5.54	10.55	14.37	8.98	1.16	809.
8.000	6.75	12.62	0.1200	5.79	12.33	16.72	10.51	1.31	807.
9.000	7.98	14.58	0.1202	5.96	13.77	18.84	12.09	1.32	803.
10.000	9.28	15.59	0.1034	6.00	14.06	19.46	13.56	1.42	799.
11.000	10.02	14.03	0.0752	5.49	12.71	17.96	12.89	1.42	795.
12.000	9.62	11.32	0.0722	4.63	10.39	15.42	10.60	1.51	788.
13.000	8.85	9.11	0.0220	4.06	8.56	13.51	8.28	1.23	786.
14.000	8.36	7.72	0.0003	3.77	7.29	12.19	6.95	1.10	782.
15.000	7.83	6.54	-0.0222	3.36	6.30	10.98	5.87	1.06	779.
16.000	7.47	5.76	0.0078	2.98	5.74	10.13	5.31	1.10	771.
17.000	7.06	5.07	0.0008	2.59	5.02	9.31	4.56	1.00	728.
18.000	6.70	4.56	0.0174	2.20	4.55	8.63	4.10	0.88	728.
19.000	6.42	4.16	0.0225	1.87	4.11	8.07	3.71	0.56	721.
20.000	6.21	3.98	0.0451	1.54	3.78	7.62	3.59	0.49	719.
21.000	6.04	3.85	0.0214	1.21	3.58	7.26	3.59	0.28	710.
22.000	5.90	3.65	0.0405	0.91	3.52	7.02	3.48	0.27	703.
23.000	5.80	3.64	0.0534	0.47	3.59	6.92	3.47	0.54	694.
24.000	5.77	3.81	0.0439	0.17	3.56	6.94	3.51	0.40	688.
25.000	6.00	3.83	0.0657	-0.18	3.70	7.24	3.46	0.34	663.
26.000	6.32	4.28	0.0913	-0.46	3.88	7.66	3.86	0.48	641.
27.000	6.62	4.66	0.0824	-0.71	4.03	8.04	4.20	0.42	579.
28.000	6.82	4.85	0.1504	-1.03	4.16	8.34	4.31	0.52	544.
29.000	7.04	5.14	0.1612	-0.94	4.06	8.58	4.44	0.54	455.
30.000	7.40	5.44	0.1995	-0.85	4.13	9.00	4.60	0.53	384.

TABLE A-10. October Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	-0.20	1.78	0.3323	-0.77	2.27	2.50	1.65	0.62	805.
1.000	-1.12	5.91	0.0848	1.63	3.26	5.95	3.74	0.95	845.
2.000	1.06	6.38	0.2438	3.09	4.56	7.39	4.19	1.01	842.
3.000	2.65	6.56	0.2323	4.05	5.56	8.68	4.69	0.76	842.
4.000	3.66	7.09	0.1232	4.45	6.61	9.88	5.41	0.80	840.
5.000	4.58	8.09	0.0155	4.78	7.79	11.38	6.35	0.89	840.
6.000	5.50	9.36	0.0037	5.45	9.44	13.29	7.74	0.89	839.
7.000	6.35	10.87	-0.0013	5.86	10.94	15.23	8.96	0.95	836.
8.000	7.39	12.35	-0.0034	6.27	12.08	17.00	10.14	0.96	829.
9.000	8.49	13.34	-0.0139	6.22	12.90	17.99	11.45	1.14	823.
10.000	9.65	12.64	-0.0325	5.71	12.19	17.25	11.68	1.59	815.
11.000	9.94	10.86	-0.0518	5.00	10.61	15.62	10.12	1.80	809.
12.000	9.93	8.82	-0.0394	4.48	8.88	14.43	8.19	1.52	807.
13.000	9.85	7.51	-0.0587	4.18	8.03	13.68	6.94	1.12	805.
14.000	10.15	6.82	-0.0772	3.93	7.54	13.48	6.10	0.71	804.
15.000	10.27	6.20	-0.0701	3.69	7.08	13.20	5.52	0.50	801.
16.000	10.50	5.91	-0.0679	3.53	6.70	13.10	5.29	0.29	768.
17.000	10.72	5.61	-0.0855	3.20	6.47	13.05	5.07	0.28	754.
18.000	11.11	5.63	-0.0983	2.79	6.44	13.25	5.36	0.48	753.
19.000	11.47	5.76	-0.1139	2.21	6.24	13.34	5.52	0.45	745.
20.000	11.85	5.99	-0.1079	1.69	6.27	13.58	5.84	0.44	739.
21.000	12.18	6.22	-0.1005	1.13	6.32	13.85	6.03	0.33	721.
22.000	12.50	6.49	-0.0457	0.40	6.43	14.14	6.32	0.35	711.
23.000	12.91	6.97	0.0005	-0.48	6.52	14.53	6.85	0.46	703.
24.000	13.25	7.43	0.0308	-1.16	6.67	14.96	7.26	0.45	680.
25.000	13.85	7.90	0.0607	-1.80	6.96	15.71	7.68	0.54	648.
26.000	14.52	8.45	0.0821	-2.62	7.28	16.62	8.09	0.56	606.
27.000	15.39	9.08	0.1064	-3.41	7.73	17.83	8.53	0.61	546.
28.000	15.86	9.28	0.1472	-3.80	8.11	18.55	8.57	0.55	490.
29.000	17.14	9.90	0.1300	-4.23	8.51	19.90	9.26	0.70	390.
30.000	18.02	10.10	0.1994	-4.74	8.73	20.95	9.32	0.76	306.

TABLE A-11. November Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	-0.17	1.37	0.4867	-0.57	1.60	1.61	1.41	1.13	776.
1.000	-2.12	6.50	-0.0527	2.11	3.49	6.80	4.12	0.89	811.
2.000	1.06	7.21	0.1841	2.96	5.17	8.03	4.90	0.99	811.
3.000	2.98	7.57	0.2067	3.29	6.60	9.53	5.45	0.88	811.
4.000	4.21	8.08	0.1646	3.58	7.82	10.96	6.07	0.89	811.
5.000	5.47	9.31	0.1171	3.87	9.68	12.99	7.52	0.82	811.
6.000	6.73	10.95	0.0702	4.17	11.93	15.38	9.38	0.79	810.
7.000	7.80	12.76	0.0257	4.18	13.71	17.47	11.13	0.85	807.
8.000	8.83	14.35	0.0113	4.31	15.15	19.21	12.75	0.95	802.
9.000	9.80	14.91	0.0081	4.21	15.59	19.74	13.76	1.12	793.
10.000	10.53	13.88	0.0152	3.78	14.74	18.89	13.36	1.35	789.
11.000	10.71	11.73	-0.0520	3.30	12.95	17.40	11.31	1.29	786.
12.000	10.79	9.57	-0.1445	3.22	10.81	15.94	9.00	1.23	780.
13.000	11.05	8.22	-0.1926	2.94	9.76	15.26	7.77	1.10	777.
14.000	11.50	7.37	-0.1864	2.60	8.91	14.98	6.94	0.81	772.
15.000	12.00	7.08	-0.2439	2.36	8.53	15.20	6.45	0.93	763.
16.000	12.65	6.87	-0.2531	1.95	8.59	15.69	6.21	0.57	707.
17.000	13.25	6.91	-0.2625	1.56	8.60	16.13	6.26	0.52	697.
18.000	13.82	7.17	-0.2421	1.19	8.64	16.56	6.66	0.41	692.
19.000	14.26	7.54	-0.2521	0.75	8.77	16.97	7.05	0.41	685.
20.000	14.91	8.15	-0.2568	0.13	9.14	17.60	7.90	0.51	681.
21.000	15.69	8.83	-0.2220	-0.55	9.75	18.47	8.85	0.39	669.
22.000	16.27	9.49	-0.1697	-1.21	10.38	19.18	9.80	0.40	650.
23.000	16.62	10.14	-0.1465	-1.92	11.10	19.76	10.74	0.42	628.
24.000	17.14	10.90	-0.1763	-2.34	11.45	20.44	11.45	0.44	593.
25.000	18.03	11.89	-0.1382	-2.76	12.05	21.60	12.33	0.47	548.
26.000	18.51	12.68	-0.1629	-2.98	12.70	22.44	13.03	0.50	514.
27.000	19.45	13.54	-0.1364	-3.44	13.68	23.86	13.82	0.51	461.
28.000	19.29	14.10	-0.1411	-3.14	13.76	23.87	14.14	0.61	381.
29.000	19.60	14.56	-0.0922	-2.59	13.98	24.29	14.41	0.64	289.
30.000	20.49	15.40	-0.1960	-3.37	15.05	25.74	15.20	0.69	220.

TABLE A-12. December Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	-0.25	1.20	0.3495	-0.69	1.54	1.54	1.41	1.39	806.
1.000	-2.34	6.68	0.1082	2.03	3.55	7.00	4.20	0.97	848.
2.000	0.98	7.55	0.2935	2.99	5.50	8.48	5.02	1.16	848.
3.000	3.17	7.76	0.2128	3.28	6.80	9.81	5.56	1.06	848.
4.000	4.82	8.22	0.0745	3.24	7.74	11.13	6.10	0.92	847.
5.000	6.29	9.16	-0.0046	3.53	9.42	13.17	7.14	0.77	846.
6.000	7.75	10.97	-0.0951	3.83	11.31	15.64	8.84	0.97	843.
7.000	9.12	12.77	-0.1188	4.10	13.03	17.95	10.50	1.11	834.
8.000	10.75	13.87	-0.1073	4.65	14.03	19.60	11.93	1.13	829.
9.000	11.91	13.57	-0.0849	4.58	14.07	19.82	12.34	1.35	822.
10.000	12.76	12.21	-0.1073	4.15	12.48	18.84	11.39	1.36	815.
11.000	13.26	10.22	-0.1174	4.09	10.99	18.04	9.61	1.18	810.
12.000	13.87	8.86	-0.1503	3.56	9.59	17.57	8.16	0.79	807.
13.000	14.76	8.18	-0.1778	3.38	9.13	17.92	7.64	0.58	807.
14.000	15.97	7.95	-0.1293	3.42	8.39	18.78	7.48	0.54	799.
15.000	17.02	7.82	-0.1150	3.12	8.67	19.55	7.32	0.24	794.
16.000	18.03	8.15	-0.0610	2.81	8.72	20.41	7.67	0.12	691.
17.000	19.44	8.32	-0.0583	2.34	9.03	21.74	7.85	0.17	680.
18.000	20.59	8.81	-0.0584	1.87	9.35	22.88	8.30	0.08	673.
19.000	21.94	9.33	-0.0408	1.39	9.69	24.24	8.73	0.07	663.
20.000	23.37	9.95	-0.0379	0.72	10.21	25.81	9.15	0.09	648.
21.000	24.79	10.48	-0.0555	0.05	10.72	27.35	9.53	0.10	619.
22.000	25.80	11.10	-0.0505	-0.54	11.29	28.58	9.98	0.08	599.
23.000	27.08	12.04	-0.0682	-1.50	12.10	30.25	10.58	0.15	575.
24.000	28.38	12.90	-0.0877	-2.26	13.16	32.03	11.13	0.21	536.
25.000	29.76	13.69	-0.1083	-3.11	14.41	33.88	11.89	0.05	489.
26.000	30.96	14.53	-0.1296	-4.13	15.68	35.60	12.85	0.01	446.
27.000	32.18	15.46	-0.1395	-4.66	16.61	37.33	13.35	-0.21	395.
28.000	32.83	17.21	-0.1286	-6.28	17.54	38.68	14.94	0.10	323.
29.000	32.53	17.03	-0.1691	-7.13	18.96	39.12	15.05	-0.17	243.
30.000	32.47	17.51	-0.2239	-8.45	20.37	39.91	15.86	-0.17	174.

TABLE A-13. Annual Statistical Wind Data, Fairbanks.

Z KM	MEAN U M/S	S.D. U M/S	R(U,V)	MEAN V M/S	S.D. V M/S	MEAN W M/S	S.D. W M/S	SKEW W	#OBS
0.000	0.00	0.00	0.0000	0.00	0.00	0.00	0.00	0.00	0.
0.135	0.07	2.16	0.0055	-0.41	2.32	2.59	1.86	0.95	9523.
1.000	-0.49	6.12	0.0356	1.47	3.31	5.97	3.85	1.10	9976.
2.000	1.22	6.55	-0.0986	2.50	4.71	7.26	4.46	1.14	9971.
3.000	2.38	6.92	-0.1798	3.04	5.82	8.46	4.97	1.02	9970.
4.000	3.28	7.60	-0.2089	3.31	6.83	9.66	5.68	1.01	9961.
5.000	4.10	8.76	-0.2041	3.59	8.24	11.30	6.83	1.08	9956.
6.000	4.96	10.30	-0.1899	3.89	9.87	13.23	8.26	1.15	9917.
7.000	5.84	11.91	-0.1743	4.10	11.51	15.21	9.68	1.22	9853.
8.000	6.72	13.31	-0.1683	4.28	12.83	16.92	10.91	1.27	9783.
9.000	7.60	13.91	-0.1729	4.25	13.43	17.76	11.57	1.33	9730.
10.000	8.24	13.34	-0.1891	3.89	12.72	17.10	11.40	1.45	9678.
11.000	8.43	11.66	-0.2244	3.42	11.03	15.43	10.07	1.42	9630.
12.000	8.31	9.87	-0.2759	3.02	9.23	13.70	8.46	1.22	9595.
13.000	8.27	9.02	-0.3070	2.74	8.18	12.81	7.73	1.02	9566.
14.000	8.33	8.82	-0.3087	2.48	7.60	12.32	7.68	0.99	9521.
15.000	8.36	8.85	-0.2888	2.20	7.21	11.95	7.88	1.06	9471.
16.000	8.10	9.01	-0.2497	1.92	6.93	11.45	8.19	1.16	9006.
17.000	8.23	9.48	-0.2071	1.63	6.84	11.44	8.72	1.27	8658.
18.000	8.18	10.04	-0.1541	1.29	6.83	11.31	9.36	1.36	8637.
19.000	8.13	10.70	-0.1025	0.92	6.82	11.31	9.99	1.44	8522.
20.000	7.97	11.43	-0.0489	0.49	6.96	11.40	10.61	1.49	8468.
21.000	7.84	12.17	-0.0053	0.06	7.20	11.62	11.24	1.55	8321.
22.000	7.60	12.80	0.0285	-0.35	7.39	11.85	11.64	1.58	8170.
23.000	7.36	13.56	0.0600	-0.85	7.68	12.23	12.17	1.65	8016.
24.000	7.05	14.19	0.0793	-1.27	7.93	12.57	12.55	1.71	7765.
25.000	6.72	14.77	0.0876	-1.59	8.25	12.98	12.85	1.74	7387.
26.000	6.35	15.33	0.0913	-1.89	8.57	13.40	13.14	1.78	7043.
27.000	6.01	16.04	0.0889	-2.14	9.02	13.95	13.60	1.82	6465.
28.000	5.43	16.28	0.0842	-2.34	9.27	14.14	13.64	1.91	5800.
29.000	4.68	16.35	0.0728	-2.42	9.53	14.22	13.55	1.99	4869.
30.000	3.93	16.43	0.0620	-2.52	9.72	14.31	13.47	2.08	4002.

APPENDIX B

Fairbanks Thermodynamics Statistics Tables

Tables B-1 through B-13 provide thermodynamics statistics (monthly and annual) for Fairbanks. They were prepared as described in Chapter 3.

TABLE B-1. January Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1013.384	14.776	0.1168	254.86	9.76	0.00	1386.75	63.84	0.14	713.	713.	713.
0.135	995.206	14.245	0.1234	255.37	9.37	-0.04	1358.96	59.55	0.15	715.	715.	715.
1.000	888.299	12.305	0.1714	263.41	8.59	-0.75	1174.35	43.09	-0.03	774.	776.	776.
2.000	780.013	11.379	0.1290	261.82	6.95	-0.65	1037.72	27.63	0.46	775.	775.	775.
3.000	683.820	11.047	0.0426	256.28	6.26	-0.50	929.37	19.44	0.31	775.	775.	775.
4.000	597.142	10.848	-0.0054	249.92	6.22	-0.39	832.34	15.04	0.06	775.	775.	775.
5.000	520.125	10.751	-0.0834	243.21	6.37	-0.30	745.03	12.11	-0.03	775.	775.	775.
6.000	451.151	10.745	-0.1279	236.42	6.24	-0.20	664.83	9.96	-0.12	772.	772.	772.
7.000	389.760	10.568	-0.1292	229.60	5.62	0.02	591.38	8.67	-0.28	769.	769.	769.
8.000	334.914	9.887	-0.0396	223.33	4.48	0.25	522.40	9.81	-0.81	766.	766.	766.
9.000	287.268	9.055	0.0178	218.91	3.58	0.33	457.19	13.64	-0.71	760.	760.	760.
10.000	245.599	7.722	0.0673	217.31	4.94	0.03	393.98	16.75	-0.06	753.	753.	753.
11.000	209.927	6.405	-0.0015	218.46	5.89	-0.37	335.07	15.51	0.56	750.	750.	750.
12.000	179.635	5.351	-0.2138	219.98	5.31	-0.28	284.66	11.46	0.82	747.	747.	747.
13.000	153.825	4.589	-0.4441	220.72	4.98	-0.10	242.89	8.50	0.54	746.	746.	746.
14.000	131.764	4.035	-0.6412	220.85	5.00	-0.14	207.90	6.77	0.26	739.	739.	739.
15.000	112.856	3.583	-0.7936	220.64	5.29	-0.17	178.24	5.68	0.22	737.	737.	737.
16.000	96.648	3.246	-0.8465	220.47	5.59	-0.20	152.76	4.93	0.16	656.	656.	656.
17.000	82.663	2.926	-0.9309	220.08	5.99	-0.23	130.88	4.15	0.03	634.	634.	634.
18.000	70.815	2.628	-0.9696	219.99	6.34	-0.27	112.17	3.56	-0.19	627.	627.	627.
19.000	60.622	2.407	-0.9681	219.81	6.79	-0.36	96.10	3.09	-0.32	615.	615.	615.
20.000	51.981	2.125	-0.8875	219.89	7.18	-0.37	82.38	2.66	-0.51	600.	600.	600.
21.000	44.538	1.946	-0.8361	219.84	7.69	-0.35	70.59	2.35	-0.69	588.	588.	588.
22.000	38.175	1.779	-0.7249	219.86	8.26	-0.39	60.50	2.04	-0.79	572.	572.	572.
23.000	32.717	1.634	-0.6481	220.06	8.85	-0.35	51.80	1.80	-0.97	560.	560.	560.
24.000	28.089	1.504	-0.6086	220.52	9.26	-0.41	44.38	1.58	-1.07	528.	528.	528.
25.000	24.084	1.376	-0.5518	220.92	9.63	-0.46	37.98	1.42	-1.17	495.	495.	495.
26.000	20.733	1.217	-0.5023	221.68	9.69	-0.40	32.58	1.23	-1.19	463.	463.	463.
27.000	17.832	1.135	-0.4906	222.41	10.02	-0.34	27.92	1.13	-1.16	405.	405.	405.
28.000	15.349	1.060	-0.4628	223.30	10.35	-0.36	23.93	1.06	-1.17	350.	350.	350.
29.000	13.231	0.979	-0.4849	224.15	10.58	-0.41	20.56	0.99	-1.28	303.	303.	303.
30.000	11.421	0.821	-0.2855	224.83	10.45	-0.30	17.69	0.82	-0.88	251.	251.	251.

TABLE B-2. February Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1013.933	14.228	0.0679	254.47	11.01	0.18	1390.17	67.67	0.05	704.	704.	704.
0.135	995.664	13.810	0.0877	254.79	10.63	0.16	1363.15	63.27	0.06	705.	705.	705.
1.000	887.824	12.781	0.0742	260.44	9.92	-0.24	1187.99	46.21	-0.02	752.	753.	753.
2.000	778.594	12.289	0.1851	259.32	7.73	-0.14	1046.00	28.62	0.37	753.	753.	753.
3.000	681.703	12.280	0.2545	254.07	7.08	0.03	934.73	20.20	0.31	753.	753.	753.
4.000	594.566	12.262	0.3277	247.84	7.02	0.15	835.79	15.32	0.23	753.	753.	753.
5.000	517.361	12.222	0.3547	241.25	6.93	0.20	747.13	11.90	0.11	752.	752.	752.
6.000	448.026	12.115	0.3775	234.48	6.41	0.45	665.67	9.66	0.01	746.	746.	746.
7.000	386.650	11.768	0.4421	228.08	5.64	0.67	590.54	9.87	-0.53	742.	742.	742.
8.000	332.091	10.910	0.5867	222.47	4.68	0.65	519.99	12.29	-0.88	740.	740.	740.
9.000	284.712	9.839	0.6796	219.19	4.30	0.33	452.64	16.46	-0.37	735.	735.	735.
10.000	243.557	8.306	0.7453	218.84	5.44	0.32	388.06	18.56	0.33	731.	731.	731.
11.000	208.455	6.798	0.6522	220.26	6.05	-0.40	330.07	16.94	1.10	729.	729.	729.
12.000	178.597	5.594	0.3910	221.59	5.84	-0.78	281.03	12.95	1.36	727.	727.	727.
13.000	153.131	4.768	0.1329	222.68	5.11	-0.66	239.67	8.83	0.98	725.	725.	725.
14.000	131.337	4.179	-0.1334	222.90	5.21	-0.80	205.34	6.92	0.81	723.	723.	723.
15.000	112.668	3.718	-0.3868	222.82	5.45	-0.94	176.20	5.70	0.73	723.	723.	723.
16.000	96.761	3.384	-0.6179	222.74	5.73	-0.92	151.37	4.98	0.71	651.	651.	651.
17.000	82.984	3.034	-0.8256	222.67	5.92	-1.02	129.85	4.16	0.60	644.	644.	644.
18.000	71.246	2.687	-0.9678	222.87	5.94	-0.95	111.38	3.55	0.34	635.	635.	635.
19.000	61.126	2.446	-1.1062	222.71	6.25	-0.77	95.63	3.13	0.06	630.	630.	630.
20.000	52.436	2.233	-1.2085	222.65	6.54	-0.72	82.05	2.74	-0.20	627.	627.	627.
21.000	45.005	2.036	-1.2736	222.64	6.78	-0.60	70.42	2.41	-0.45	616.	616.	616.
22.000	38.603	1.868	-1.2660	222.50	7.08	-0.52	60.44	2.16	-0.72	608.	608.	608.
23.000	33.159	1.648	-1.2025	222.60	7.26	-0.35	51.89	1.91	-0.98	595.	595.	595.
24.000	28.479	1.490	-1.1573	222.90	7.54	-0.26	44.51	1.70	-1.18	568.	568.	568.
25.000	24.462	1.340	-1.0282	223.17	7.86	-0.20	38.18	1.48	-1.28	556.	556.	556.
26.000	21.045	1.186	-0.9675	223.67	8.29	-0.09	32.77	1.32	-1.43	531.	531.	531.
27.000	18.078	1.103	-0.8886	224.09	8.91	0.00	28.10	1.20	-1.51	473.	473.	473.
28.000	15.568	1.020	-0.8104	224.81	9.40	0.03	24.12	1.10	-1.71	416.	416.	416.
29.000	13.443	0.919	-0.7724	225.96	9.98	-0.09	20.72	0.96	-1.83	353.	353.	353.
30.000	11.577	0.805	-0.5029	226.51	10.33	-0.21	17.80	0.85	-1.83	304.	304.	304.

TABLE B-3. March Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1010.661	9.732	0.2298	263.82	8.43	-0.33	1335.07	48.64	0.57	800.	800.	800.
0.135	993.114	9.443	0.2069	263.56	8.06	-0.33	1313.04	45.27	0.55	800.	800.	800.
1.000	887.751	9.049	-1.0441	263.54	6.37	-0.39	1172.25	32.19	-0.99	840.	843.	843.
2.000	779.223	8.165	0.0521	259.96	5.20	-0.17	1043.83	19.85	0.42	843.	843.	843.
3.000	682.429	8.104	0.0893	254.22	4.91	0.10	934.97	14.92	0.31	843.	843.	843.
4.000	595.196	8.072	0.1750	247.89	5.08	0.26	836.41	12.40	0.17	842.	842.	842.
5.000	517.933	8.041	0.2515	241.38	5.28	0.31	747.55	10.62	0.10	842.	842.	842.
6.000	448.714	8.168	0.2933	234.67	5.30	0.29	666.19	9.23	-0.17	840.	840.	840.
7.000	387.248	8.089	0.3577	228.16	4.92	0.36	591.33	8.01	-0.47	834.	834.	834.
8.000	332.610	7.529	0.4581	222.63	4.07	0.39	520.50	9.09	-0.62	828.	828.	828.
9.000	285.261	6.836	0.5443	220.11	3.95	0.32	451.60	13.11	-0.18	823.	823.	823.
10.000	244.317	5.674	0.5461	221.06	5.00	-0.14	385.30	14.98	0.64	820.	820.	820.
11.000	209.495	4.554	0.3885	223.20	5.05	-0.82	327.22	12.37	1.24	819.	819.	819.
12.000	179.856	3.734	0.2000	224.67	4.34	-0.91	279.01	8.80	1.26	817.	817.	817.
13.000	154.505	3.163	0.0954	225.32	3.73	-0.33	238.95	6.40	0.67	817.	817.	817.
14.000	132.793	2.710	0.0621	225.44	3.45	-0.20	205.25	5.14	0.39	809.	809.	809.
15.000	114.117	2.349	0.0647	225.47	3.24	-0.01	176.35	4.28	0.08	807.	807.	807.
16.000	98.082	2.070	0.1076	225.37	3.24	0.04	151.64	3.68	-0.14	774.	774.	774.
17.000	84.257	1.798	0.2010	225.28	3.33	0.04	130.31	3.12	-0.32	766.	766.	766.
18.000	72.395	1.574	0.2997	225.15	3.45	0.18	112.03	2.63	-0.44	763.	763.	763.
19.000	62.214	1.405	0.3952	225.00	3.60	0.27	96.34	2.21	-0.51	751.	751.	751.
20.000	53.447	1.256	0.4632	224.87	3.83	0.25	82.81	1.86	-0.49	750.	750.	750.
21.000	45.917	1.138	0.4843	224.82	4.07	0.13	71.16	1.59	-0.39	740.	740.	740.
22.000	39.440	1.040	0.4777	224.66	4.44	0.14	61.16	1.35	-0.31	733.	733.	733.
23.000	33.875	0.957	0.4466	224.68	4.71	-0.03	52.53	1.16	-0.10	729.	729.	729.
24.000	29.107	0.880	0.4043	224.71	5.03	-0.15	45.12	1.00	0.17	712.	712.	712.
25.000	25.014	0.813	0.3893	224.83	5.30	-0.11	38.76	0.87	0.34	694.	694.	694.
26.000	21.497	0.746	0.3711	225.07	5.71	-0.03	33.27	0.78	0.44	682.	682.	682.
27.000	18.479	0.693	0.3314	225.32	6.07	-0.02	28.57	0.72	0.34	611.	611.	611.
28.000	15.894	0.625	0.3444	225.81	6.39	-0.04	24.52	0.63	0.51	553.	553.	553.
29.000	13.673	0.572	0.2824	226.21	6.71	-0.15	21.05	0.56	0.71	479.	479.	479.
30.000	11.766	0.532	0.2202	226.61	7.05	-0.14	18.09	0.52	0.81	413.	413.	413.

TABLE B-4. April Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1010.979	9.923	0.0733	273.51	7.31	-0.57	1287.16	41.26	0.81	804.	804.	804.
0.135	994.019	9.623	0.0618	272.74	7.06	-0.57	1269.11	39.05	0.82	804.	804.	804.
1.000	891.060	8.147	0.0307	268.18	6.07	-0.70	1156.90	29.41	0.83	820.	820.	820.
2.000	783.360	7.493	0.1063	262.16	4.81	-0.43	1040.39	19.36	0.75	820.	820.	820.
3.000	686.813	7.286	0.2363	255.91	4.47	0.13	934.62	13.69	0.33	820.	820.	820.
4.000	599.623	7.338	0.3840	249.57	4.82	0.45	836.87	11.24	0.05	820.	820.	820.
5.000	522.170	7.439	0.5093	242.90	5.15	0.58	748.89	9.70	-0.09	820.	820.	820.
6.000	452.854	7.622	0.5839	236.11	5.28	0.69	668.22	8.42	-0.19	820.	820.	820.
7.000	391.150	7.695	0.6854	229.40	5.13	0.89	594.05	7.34	-0.45	818.	818.	818.
8.000	336.205	7.417	0.8575	223.47	4.57	0.89	524.14	7.64	-0.84	813.	813.	813.
9.000	288.454	6.895	0.9682	220.48	3.83	0.33	455.83	11.06	-0.40	810.	810.	810.
10.000	247.097	5.874	1.0759	221.27	4.04	-0.17	389.22	13.54	0.61	809.	809.	809.
11.000	211.903	4.767	1.0415	223.12	4.28	-0.72	331.06	12.39	1.30	806.	806.	806.
12.000	181.894	3.823	0.8767	224.29	3.80	-0.99	282.65	9.42	1.58	805.	805.	805.
13.000	156.212	3.128	0.7079	224.87	3.13	-0.58	242.08	6.95	1.25	805.	805.	805.
14.000	134.203	2.579	0.5987	224.90	2.98	-0.43	207.94	5.59	1.00	801.	801.	801.
15.000	115.277	2.137	0.4879	224.72	2.97	-0.34	178.75	4.64	0.83	799.	799.	799.
16.000	99.060	1.800	0.3558	224.50	3.14	-0.16	153.76	3.91	0.64	765.	765.	765.
17.000	85.021	1.505	0.2685	224.18	3.14	-0.09	132.15	3.15	0.60	750.	750.	750.
18.000	73.001	1.284	0.1644	223.98	3.11	0.00	113.56	2.51	0.48	750.	750.	750.
19.000	62.673	1.116	0.0742	223.68	3.15	0.20	97.63	2.05	0.41	749.	749.	749.
20.000	53.790	0.982	0.0157	223.43	3.07	0.35	83.88	1.62	0.40	747.	747.	747.
21.000	46.166	0.880	-0.0318	223.14	3.10	0.43	72.08	1.30	0.32	735.	735.	735.
22.000	39.604	0.802	-0.0360	222.87	3.22	0.33	61.91	1.07	0.26	724.	724.	724.
23.000	33.975	0.732	-0.0287	222.66	3.34	0.38	53.16	0.88	0.18	717.	717.	717.
24.000	29.155	0.670	-0.0259	222.57	3.46	0.39	45.63	0.74	0.08	695.	695.	695.
25.000	25.002	0.620	0.0163	222.60	3.54	0.30	39.13	0.64	-0.01	675.	675.	675.
26.000	21.446	0.571	0.0567	222.82	3.70	0.30	33.53	0.57	-0.16	659.	659.	659.
27.000	18.414	0.519	0.0909	223.39	3.75	0.34	28.72	0.51	-0.23	589.	589.	589.
28.000	15.816	0.487	0.1574	224.10	3.93	0.33	24.58	0.47	-0.25	535.	535.	535.
29.000	13.572	0.451	0.1900	224.90	4.10	0.27	21.02	0.43	-0.19	465.	465.	465.
30.000	11.650	0.413	0.2423	225.88	4.16	0.32	17.97	0.42	-0.07	399.	399.	399.

TABLE B-5. May Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1009.253	7.852	0.0487	284.01	5.68	0.19	1235.84	27.31	-0.01	833.	833.	833.
0.135	992.958	7.711	0.0394	283.02	5.47	0.19	1220.18	25.86	-0.01	833.	833.	833.
1.000	893.484	6.997	0.0320	277.36	4.37	-0.02	1120.41	17.98	0.10	835.	836.	835.
2.000	788.631	6.777	0.0375	269.32	4.04	0.24	1018.71	14.39	-0.04	835.	836.	835.
3.000	693.888	6.628	0.0449	262.13	3.88	0.52	921.40	11.38	-0.13	835.	835.	835.
4.000	607.814	6.672	0.1644	255.61	4.22	0.39	828.07	10.04	-0.03	836.	836.	836.
5.000	530.957	6.666	0.2272	248.86	4.54	0.26	743.14	8.85	0.03	836.	836.	836.
6.000	462.009	6.778	0.2458	241.73	4.79	0.17	665.80	7.87	-0.03	835.	835.	835.
7.000	400.501	6.839	0.1969	234.50	4.87	0.17	595.02	6.76	-0.09	823.	823.	823.
8.000	345.164	6.829	0.3120	227.44	4.42	0.40	528.71	5.96	-0.29	819.	819.	819.
9.000	296.762	6.385	0.3532	222.04	3.42	0.55	465.63	8.62	-0.96	818.	818.	818.
10.000	254.286	5.525	0.5245	221.00	3.98	0.17	401.03	13.06	-0.13	813.	813.	813.
11.000	218.058	4.431	0.5730	223.01	4.68	-0.62	340.87	12.67	0.72	807.	807.	807.
12.000	187.186	3.515	0.4909	224.82	3.74	-1.07	290.18	8.99	1.08	801.	801.	801.
13.000	160.820	2.875	0.3947	225.31	2.87	-0.77	248.72	6.38	0.86	800.	800.	800.
14.000	138.171	2.390	0.3358	225.18	2.41	-0.56	213.79	4.88	0.63	796.	796.	796.
15.000	118.701	2.010	0.2902	224.87	2.21	-0.48	183.91	3.93	0.50	794.	794.	794.
16.000	101.993	1.691	0.2819	224.60	2.17	-0.32	158.21	3.17	0.45	789.	789.	789.
17.000	87.594	1.450	0.2465	224.48	2.16	-0.30	135.95	2.60	0.45	756.	756.	756.
18.000	75.226	1.252	0.2381	224.50	2.08	-0.25	116.74	2.11	0.42	755.	755.	755.
19.000	64.623	1.093	0.2094	224.47	2.06	-0.10	100.29	1.74	0.43	743.	743.	743.
20.000	55.497	0.957	0.1749	224.37	2.01	-0.18	86.17	1.43	0.36	740.	740.	740.
21.000	47.669	0.850	0.1268	224.37	2.06	-0.19	74.02	1.20	0.32	735.	735.	735.
22.000	40.936	0.760	0.0771	224.45	2.11	-0.26	63.53	1.00	0.23	720.	720.	720.
23.000	35.158	0.679	0.0602	224.62	2.19	-0.31	54.53	0.86	0.20	715.	715.	715.
24.000	30.206	0.603	0.0174	224.88	2.35	-0.35	46.79	0.73	0.10	701.	701.	701.
25.000	25.967	0.550	0.0377	225.47	2.47	-0.44	40.12	0.64	0.10	674.	674.	674.
26.000	22.320	0.499	0.0011	226.20	2.61	-0.50	34.37	0.57	0.12	662.	662.	662.
27.000	19.201	0.455	-0.0222	227.24	2.74	-0.35	29.44	0.50	0.10	616.	616.	616.
28.000	16.543	0.412	-0.0175	228.64	2.86	-0.29	25.20	0.44	0.08	570.	570.	570.
29.000	14.259	0.379	-0.0181	230.26	3.00	-0.33	21.57	0.40	0.10	518.	518.	518.
30.000	12.295	0.357	-0.0289	232.01	3.04	-0.30	18.46	0.37	0.10	452.	452.	452.

TABLE B-6. June Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1010.095	6.507	-0.0917	289.19	5.13	0.35	1212.89	23.91	-0.23	798.	798.	798.
0.135	994.082	6.384	-0.0922	288.19	4.93	0.35	1197.93	22.62	-0.23	800.	800.	800.
1.000	896.256	5.621	-0.1953	282.37	3.97	0.06	1102.90	16.34	-0.03	816.	816.	816.
2.000	793.029	5.361	-0.2975	274.53	3.45	0.07	1004.18	12.25	-0.10	815.	815.	815.
3.000	699.595	5.210	-0.3659	267.66	3.13	0.05	909.23	9.16	-0.11	814.	814.	814.
4.000	614.627	5.238	-0.3154	261.44	3.12	0.00	818.32	7.40	-0.14	814.	814.	814.
5.000	538.542	5.161	-0.3010	254.94	3.33	0.05	735.59	6.58	-0.22	814.	814.	814.
6.000	470.197	5.207	-0.2645	247.85	3.60	0.09	660.75	6.12	-0.16	812.	812.	812.
7.000	408.948	5.109	-0.2225	240.38	3.87	0.24	592.63	5.82	-0.13	808.	808.	808.
8.000	353.855	5.186	-0.1595	232.77	3.88	0.46	529.60	5.27	-0.19	786.	786.	786.
9.000	305.014	4.938	-0.0016	225.63	3.66	0.54	470.97	6.09	-0.87	785.	785.	785.
10.000	261.746	4.505	0.2076	221.25	3.83	0.54	412.24	9.68	-0.89	782.	782.	782.
11.000	224.437	3.719	0.3911	222.20	4.80	-0.01	352.10	11.57	0.14	778.	778.	778.
12.000	192.642	2.927	0.3739	225.08	3.88	-0.80	298.29	8.44	1.06	776.	776.	776.
13.000	165.561	2.361	0.1896	226.05	2.72	-0.64	255.20	5.48	0.97	775.	775.	775.
14.000	142.346	1.978	0.0746	226.02	2.16	-0.44	219.43	4.09	0.70	773.	773.	773.
15.000	122.364	1.671	0.0083	225.84	1.88	-0.39	188.76	3.22	0.53	771.	771.	771.
16.000	105.182	1.424	-0.0249	225.69	1.71	-0.34	162.37	2.60	0.34	771.	771.	771.
17.000	90.433	1.207	-0.0032	225.75	1.65	-0.46	139.56	2.15	0.26	718.	718.	718.
18.000	77.736	1.040	0.0241	225.93	1.58	-0.16	119.87	1.77	0.17	715.	715.	715.
19.000	66.841	0.898	0.0162	226.17	1.47	-0.28	102.96	1.47	0.09	709.	708.	709.
20.000	57.483	0.793	0.0518	226.56	1.49	-0.23	88.39	1.21	0.01	705.	705.	705.
21.000	49.449	0.696	0.0749	226.99	1.55	-0.21	75.89	1.02	-0.03	695.	695.	695.
22.000	42.563	0.622	0.1079	227.46	1.48	-0.01	65.19	0.86	-0.03	689.	689.	689.
23.000	36.633	0.555	0.1154	227.97	1.49	0.03	55.98	0.73	-0.02	676.	676.	676.
24.000	31.532	0.494	0.1293	228.54	1.55	-0.10	48.06	0.63	0.02	675.	675.	675.
25.000	27.178	0.439	0.1005	229.41	1.59	-0.09	41.27	0.55	0.03	643.	643.	643.
26.000	23.428	0.392	0.1019	230.52	1.69	-0.18	35.41	0.49	0.12	632.	632.	632.
27.000	20.210	0.347	0.0958	231.79	1.95	-0.62	30.37	0.44	0.20	612.	612.	612.
28.000	17.466	0.312	0.0599	233.45	1.93	-0.13	26.07	0.38	0.09	551.	551.	551.
29.000	15.110	0.282	0.0415	235.21	2.04	-0.38	22.38	0.35	0.13	506.	506.	506.
30.000	13.069	0.256	0.0702	237.10	2.20	-0.75	19.20	0.31	0.11	450.	450.	450.

TABLE B-7. July Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1011.764	5.608	0.1800	290.77	4.80	0.44	1207.03	21.52	-0.30	814.	814.	814.
0.135	995.859	5.506	0.1835	289.84	4.60	0.43	1192.01	20.27	-0.30	815.	815.	815.
1.000	898.539	5.015	0.0978	284.48	3.67	-0.11	1096.45	14.49	-0.17	825.	827.	826.
2.000	795.893	4.900	0.0159	277.02	3.20	-0.05	998.23	10.66	-0.12	827.	827.	827.
3.000	702.982	4.824	-0.1137	270.59	2.86	-0.09	903.43	7.63	-0.05	827.	827.	827.
4.000	618.617	4.908	-0.2045	264.80	2.99	-0.17	812.99	6.45	0.06	827.	827.	827.
5.000	543.036	4.925	-0.2169	258.67	3.22	-0.18	730.90	5.75	-0.05	827.	827.	827.
6.000	475.202	5.005	-0.2309	251.96	3.48	-0.19	656.83	5.23	-0.07	825.	825.	825.
7.000	414.158	4.980	-0.2266	244.64	3.75	-0.10	589.67	4.89	-0.12	823.	823.	823.
8.000	359.365	5.016	-0.2373	237.02	3.84	0.20	528.16	4.60	-0.33	815.	815.	815.
9.000	310.506	4.949	-0.1157	229.44	3.80	0.39	471.48	4.77	-1.50	813.	813.	813.
10.000	266.949	4.635	0.0637	223.10	3.23	0.63	416.77	7.10	-1.88	812.	810.	812.
11.000	228.959	3.982	0.3455	221.03	4.75	0.90	361.07	11.37	-0.56	805.	805.	805.
12.000	196.345	3.136	0.6309	223.73	4.82	-0.08	305.93	10.12	0.63	805.	805.	805.
13.000	168.651	2.499	0.9056	225.21	3.23	-1.00	260.89	6.72	1.03	801.	799.	801.
14.000	144.929	2.049	1.4936	225.53	2.49	-0.73	223.84	4.74	0.70	795.	793.	795.
15.000	124.568	1.737	2.4654	225.53	2.16	-0.63	192.37	3.64	0.55	793.	791.	793.
16.000	107.021	1.231	0.0979	225.62	1.88	-0.45	165.26	2.80	0.33	790.	790.	792.
17.000	92.020	1.011	0.0247	225.87	1.69	-0.20	141.94	2.19	0.04	735.	735.	737.
18.000	79.112	0.841	0.0568	226.14	1.62	0.31	121.88	1.75	-0.05	734.	734.	736.
19.000	68.019	0.704	0.1609	226.49	1.48	0.17	104.64	1.39	-0.24	725.	723.	727.
20.000	58.520	0.598	0.1748	226.92	1.41	0.12	89.85	1.11	-0.07	722.	721.	724.
21.000	50.347	0.511	0.2698	227.39	1.43	-0.30	77.15	0.95	0.64	716.	716.	718.
22.000	43.347	0.446	0.2581	227.91	1.36	-0.11	66.29	0.87	2.83	697.	697.	699.
23.000	37.326	0.389	0.2507	228.45	1.38	-0.10	56.92	0.61	0.19	685.	685.	685.
24.000	32.137	0.346	0.2575	229.15	1.39	-0.11	48.86	0.51	0.18	684.	684.	684.
25.000	27.709	0.303	0.2633	230.09	1.40	-0.11	41.95	0.43	0.19	666.	666.	666.
26.000	23.899	0.274	0.2705	231.31	1.39	-0.27	35.99	0.37	0.12	653.	653.	653.
27.000	20.619	0.245	0.2948	232.67	1.51	-0.30	30.87	0.33	0.19	652.	651.	652.
28.000	17.834	0.217	0.2660	234.20	1.54	-0.44	26.53	0.28	0.25	597.	597.	597.
29.000	15.425	0.196	0.2299	235.79	1.61	-0.40	22.79	0.25	0.25	552.	552.	552.
30.000	13.352	0.172	0.2240	237.47	1.70	-0.32	19.59	0.22	0.36	485.	485.	485.

TABLE B-8. August Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1012.209	6.975	-0.1804	287.79	5.07	0.16	1220.61	24.06	0.13	824.	824.	824.
0.135	996.132	6.820	-0.2168	286.94	4.92	0.16	1204.91	22.87	0.14	828.	828.	828.
1.000	897.937	6.210	-0.3023	282.04	4.30	0.05	1105.23	19.37	-1.26	845.	848.	848.
2.000	794.542	6.018	-0.2888	275.20	4.15	0.09	1003.51	14.28	0.35	847.	848.	847.
3.000	701.273	5.966	-0.1625	269.39	4.06	0.08	905.52	11.08	0.47	848.	848.	848.
4.000	616.695	6.173	0.0172	263.57	4.23	0.05	814.37	9.28	0.32	848.	848.	848.
5.000	541.005	6.321	0.1028	257.37	4.64	0.05	731.91	8.32	0.06	848.	848.	848.
6.000	473.076	6.583	0.1439	250.70	5.01	0.05	657.24	7.43	-0.28	844.	844.	844.
7.000	412.102	6.644	0.1689	243.60	5.32	0.11	589.30	6.59	-0.66	841.	841.	841.
8.000	357.307	6.830	0.1490	236.21	5.39	0.28	526.98	5.63	-1.31	837.	837.	837.
9.000	308.642	6.720	0.2157	228.98	5.12	0.48	469.59	5.69	-1.93	833.	833.	833.
10.000	265.349	6.368	0.3585	223.48	4.10	0.34	413.61	8.92	-1.56	827.	826.	827.
11.000	227.672	5.513	0.5449	222.12	4.49	0.18	357.23	13.04	-0.27	823.	822.	823.
12.000	195.312	4.425	0.6532	223.47	4.98	-0.59	304.72	12.56	0.72	822.	822.	822.
13.000	167.634	3.458	0.6560	224.24	4.07	-0.87	260.57	9.25	0.99	819.	819.	819.
14.000	143.958	2.754	0.6528	224.28	3.32	-0.48	223.69	6.83	0.82	818.	818.	818.
15.000	123.600	2.218	0.7424	224.05	3.12	-0.61	192.25	5.41	0.88	811.	811.	811.
16.000	106.125	1.809	0.9208	224.00	2.81	-0.64	165.09	4.15	0.85	809.	809.	809.
17.000	91.131	1.527	1.2933	224.08	2.57	-0.69	141.70	3.25	0.88	745.	745.	745.
18.000	78.235	1.201	0.1787	224.34	2.28	-0.48	121.53	2.52	1.15	742.	743.	743.
19.000	67.193	1.014	0.1149	224.62	2.05	-0.29	104.22	1.83	0.53	736.	737.	736.
20.000	57.718	0.890	0.0738	224.79	1.95	-0.29	89.45	1.44	0.49	730.	731.	730.
21.000	49.589	0.775	0.0305	224.99	1.96	-0.23	76.78	1.14	0.44	723.	724.	723.
22.000	42.608	0.689	-0.0144	225.26	1.99	-0.21	65.89	0.94	0.44	710.	711.	710.
23.000	36.620	0.620	-0.0657	225.65	2.11	0.10	56.54	0.80	0.37	699.	700.	699.
24.000	31.479	0.558	-0.0653	226.19	2.18	0.02	48.47	0.69	0.26	695.	695.	695.
25.000	27.092	0.501	-0.0969	227.14	2.17	0.06	41.54	0.59	0.17	669.	669.	669.
26.000	23.330	0.490	1.2154	228.24	2.23	0.19	35.60	0.51	0.07	659.	659.	658.
27.000	20.092	0.433	1.0147	229.38	2.26	-0.05	30.51	0.45	-0.04	636.	636.	635.
28.000	17.337	0.396	0.8926	230.64	2.33	-0.23	26.18	0.40	-0.06	588.	588.	587.
29.000	14.975	0.362	0.6969	232.06	2.46	-0.40	22.47	0.37	-0.11	542.	542.	541.
30.000	12.932	0.327	0.5906	233.59	2.55	-0.52	19.28	0.33	-0.02	484.	484.	483.

TABLE B-9. September Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1010.346	8.675	-0.3762	281.99	5.33	0.04	1245.19	28.79	0.19	778.	778.	778.
0.135	993.943	8.457	-0.3780	281.24	5.16	0.02	1228.32	27.47	0.20	778.	778.	778.
1.000	894.174	7.255	-0.3303	277.10	4.68	-0.56	1121.30	23.93	-1.00	806.	808.	808.
2.000	789.482	6.600	-0.1451	270.92	4.35	-0.51	1013.64	17.11	0.40	808.	808.	808.
3.000	695.364	6.276	-0.0026	265.12	4.13	-0.09	912.80	12.98	0.07	808.	808.	808.
4.000	610.085	6.288	0.1550	259.12	4.29	0.02	819.76	10.64	0.01	808.	808.	808.
5.000	534.012	6.315	0.2252	252.70	4.67	0.10	735.96	9.25	-0.08	808.	808.	808.
6.000	465.722	6.528	0.2507	245.86	5.04	0.14	659.86	8.07	-0.08	808.	808.	808.
7.000	404.654	6.624	0.2275	238.67	5.30	0.21	590.67	7.05	-0.04	806.	806.	806.
8.000	349.664	6.827	0.2671	231.38	5.29	0.29	526.50	5.89	-0.28	805.	805.	805.
9.000	301.320	6.637	0.3162	224.62	4.81	0.43	467.36	6.10	-1.23	799.	799.	799.
10.000	258.363	6.173	0.4379	220.39	4.07	0.32	408.46	9.94	-0.94	796.	796.	796.
11.000	221.308	5.257	0.5709	220.75	4.40	0.01	349.46	12.84	0.23	791.	791.	791.
12.000	189.681	4.226	0.5459	222.22	4.37	-0.93	297.55	11.22	0.94	785.	785.	785.
13.000	162.680	3.383	0.4406	222.88	3.41	-0.73	254.37	8.20	0.90	784.	784.	784.
14.000	139.562	2.742	0.3324	222.87	3.09	-0.56	218.22	6.48	0.82	777.	777.	777.
15.000	119.708	2.226	0.2141	222.70	2.88	-0.60	187.31	5.14	0.74	776.	776.	776.
16.000	102.693	1.809	0.1250	222.59	2.71	-0.44	160.76	4.05	0.59	774.	774.	774.
17.000	88.078	1.517	0.0364	222.47	2.55	-0.30	137.95	3.22	0.49	728.	728.	728.
18.000	75.536	1.274	-0.0462	222.29	2.40	-0.13	118.40	2.50	0.39	726.	726.	726.
19.000	64.777	1.089	-0.1171	222.06	2.35	-0.01	101.63	1.97	0.27	718.	718.	718.
20.000	55.531	0.946	-0.1376	221.72	2.41	-0.02	87.26	1.60	0.13	715.	715.	715.
21.000	47.607	0.834	-0.1530	221.46	2.51	-0.08	74.89	1.31	0.05	708.	708.	708.
22.000	40.792	0.746	-0.1571	221.23	2.58	-0.11	64.24	1.09	0.02	702.	702.	702.
23.000	34.958	0.668	-0.1520	221.19	2.73	-0.09	55.06	0.91	0.01	698.	698.	698.
24.000	29.967	0.602	-0.1479	221.36	2.82	-0.10	47.16	0.77	-0.09	691.	691.	691.
25.000	25.686	0.552	-0.1359	221.78	3.00	-0.08	40.35	0.65	-0.16	674.	674.	674.
26.000	22.022	0.506	-0.1228	222.28	3.24	-0.10	34.51	0.56	-0.19	663.	663.	663.
27.000	18.906	0.460	-0.1388	223.01	3.45	-0.10	29.54	0.49	-0.21	606.	606.	606.
28.000	16.236	0.422	-0.0850	223.87	3.64	-0.09	25.26	0.43	-0.20	565.	565.	565.
29.000	13.967	0.387	-0.1426	224.97	3.91	-0.06	21.62	0.38	-0.27	498.	498.	498.
30.000	12.003	0.354	-0.1040	226.08	4.17	-0.11	18.49	0.34	-0.31	429.	429.	429.

TABLE B-10. October Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1007.279	11.464	0.1667	270.59	7.19	-0.67	1295.89	41.44	0.68	812.	812.	812.
0.135	990.279	11.188	0.1509	270.15	6.95	-0.66	1276.09	39.26	0.64	818.	818.	818.
1.000	887.358	9.805	0.1640	268.37	6.10	-0.59	1150.56	30.35	-0.05	826.	827.	827.
2.000	780.669	8.925	0.1369	264.63	5.25	-0.68	1026.93	21.76	0.40	825.	825.	825.
3.000	685.432	8.486	0.0704	259.20	4.89	-0.55	920.78	16.41	0.28	824.	824.	824.
4.000	599.446	8.216	0.0242	252.92	4.96	-0.29	825.48	13.26	0.12	824.	824.	824.
5.000	523.011	8.049	0.0093	246.26	5.13	-0.12	739.83	11.07	-0.07	823.	823.	823.
6.000	454.400	8.094	-0.0114	239.33	5.37	0.08	661.44	9.47	-0.32	821.	821.	821.
7.000	393.280	8.083	-0.0013	232.22	5.34	0.31	590.04	8.06	-0.64	817.	817.	817.
8.000	338.469	7.798	0.1436	225.47	4.82	0.67	523.00	7.81	-0.97	815.	815.	815.
9.000	290.692	7.288	0.2491	220.55	4.00	0.79	459.21	10.31	-1.18	813.	813.	813.
10.000	248.880	6.355	0.3920	219.49	4.30	0.18	395.20	13.51	-0.12	806.	806.	806.
11.000	213.142	5.255	0.3996	220.80	4.48	-0.62	336.49	12.91	0.80	801.	801.	801.
12.000	182.670	4.285	0.3097	221.75	4.15	-1.46	287.12	10.27	1.32	796.	796.	796.
13.000	156.600	3.544	0.1780	222.19	3.27	-0.93	245.61	7.45	0.94	796.	796.	796.
14.000	134.276	2.973	0.0669	222.19	2.97	-0.65	210.57	5.83	0.76	792.	792.	792.
15.000	115.130	2.524	-0.0190	221.96	2.82	-0.65	180.73	4.75	0.64	791.	791.	791.
16.000	98.748	2.162	-0.1134	221.68	2.77	-0.58	155.21	3.94	0.45	767.	767.	767.
17.000	84.600	1.857	-0.2051	221.30	2.75	-0.47	133.19	3.18	0.26	754.	754.	754.
18.000	72.494	1.614	-0.2403	220.82	2.92	-0.50	114.38	2.64	0.12	754.	754.	754.
19.000	62.101	1.417	-0.2653	220.33	2.87	-0.62	98.20	2.27	0.14	751.	751.	751.
20.000	53.176	1.234	-0.3130	219.74	3.04	-0.62	84.32	1.92	0.04	748.	748.	748.
21.000	45.503	1.078	-0.5463	219.31	3.23	-0.48	72.28	1.60	-0.16	731.	731.	731.
22.000	38.936	0.961	-0.6024	218.90	3.41	-0.44	61.97	1.36	-0.22	725.	725.	725.
23.000	33.309	0.858	-0.6293	218.61	3.65	-0.43	53.08	1.17	-0.35	721.	721.	721.
24.000	28.512	0.767	-0.6593	218.46	3.80	-0.43	45.47	1.03	-0.40	694.	694.	694.
25.000	24.394	0.695	-0.7038	218.32	4.07	-0.42	38.92	0.88	-0.42	680.	680.	680.
26.000	20.874	0.614	-0.6925	218.19	4.24	-0.34	33.32	0.77	-0.37	666.	666.	666.
27.000	17.876	0.557	-0.7534	218.25	4.37	-0.41	28.53	0.68	-0.38	576.	576.	576.
28.000	15.313	0.504	-0.8428	218.49	4.41	-0.41	24.41	0.61	-0.42	516.	516.	516.
29.000	13.117	0.438	-0.6516	218.92	4.41	-0.29	20.87	0.54	-0.33	451.	451.	451.
30.000	11.227	0.389	-0.7047	219.33	4.46	-0.15	17.83	0.49	-0.44	385.	385.	385.

TABLE B-11. November Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1010.862	14.051	0.0601	258.46	8.85	-0.19	1363.36	56.62	0.17	761.	761.	761.
0.135	992.963	13.581	0.0682	258.69	8.45	-0.19	1337.87	52.62	0.15	762.	762.	762.
1.000	887.080	11.821	0.2305	263.75	7.41	-0.20	1171.46	35.15	0.11	800.	800.	800.
2.000	778.995	11.049	0.4101	261.63	6.22	0.03	1036.88	23.85	0.16	800.	800.	800.
3.000	682.854	10.821	0.5206	256.16	5.95	0.25	928.42	17.64	0.03	800.	800.	800.
4.000	596.211	10.686	0.5834	249.78	6.14	0.39	831.45	14.14	-0.15	800.	800.	800.
5.000	519.353	10.590	0.6365	243.17	6.39	0.44	744.05	11.76	-0.22	800.	800.	800.
6.000	450.418	10.735	0.6313	236.32	6.53	0.50	664.06	9.87	-0.29	800.	800.	800.
7.000	389.041	10.657	0.6436	229.46	6.28	0.53	590.68	8.52	-0.14	797.	797.	797.
8.000	334.396	10.194	0.7175	223.32	5.44	0.55	521.63	8.85	-0.30	794.	794.	794.
9.000	286.830	9.456	0.7367	219.44	4.29	0.16	455.37	12.79	-0.25	789.	789.	789.
10.000	245.426	8.192	0.7902	218.68	4.09	-0.06	391.18	16.42	0.42	785.	785.	785.
11.000	209.906	6.712	0.7828	219.21	5.07	-0.67	333.89	16.46	1.00	780.	780.	780.
12.000	179.699	5.394	0.6403	219.97	5.14	-1.15	284.85	13.72	1.42	775.	775.	775.
13.000	153.869	4.343	0.4247	220.45	4.55	-0.92	243.33	10.26	1.28	771.	771.	771.
14.000	131.779	3.563	0.2110	220.66	4.33	-0.62	208.16	7.93	1.07	764.	764.	764.
15.000	112.869	2.974	-0.0066	220.62	4.46	-0.52	178.31	6.37	0.97	764.	764.	764.
16.000	96.683	2.501	-0.1641	220.47	4.62	-0.53	152.84	5.23	0.92	717.	717.	717.
17.000	82.732	2.117	-0.3945	220.13	4.73	-0.44	130.98	4.16	0.78	705.	705.	705.
18.000	70.840	1.852	-0.5713	219.75	4.89	-0.36	112.34	3.40	0.60	703.	703.	703.
19.000	60.609	1.654	-0.6874	219.21	5.13	-0.35	96.35	2.80	0.40	693.	693.	693.
20.000	51.867	1.484	-0.7643	218.70	5.56	-0.37	82.65	2.35	0.26	689.	689.	689.
21.000	44.370	1.357	-0.8044	218.37	5.95	-0.35	70.81	1.99	0.07	676.	676.	676.
22.000	37.944	1.249	-0.8230	218.05	6.33	-0.32	60.64	1.68	-0.16	655.	655.	655.
23.000	32.451	1.142	-0.7231	217.73	6.69	-0.30	51.93	1.40	-0.33	649.	649.	649.
24.000	27.757	1.056	-0.6942	217.57	7.02	-0.30	44.45	1.19	-0.58	599.	599.	599.
25.000	23.707	0.999	-0.6061	217.16	7.40	-0.30	38.03	1.05	-0.80	582.	582.	582.
26.000	20.330	0.904	-0.6182	217.44	7.47	-0.43	32.57	0.92	-0.93	543.	543.	543.
27.000	17.412	0.826	-0.5906	217.44	7.48	-0.49	27.89	0.81	-1.07	477.	477.	477.
28.000	14.919	0.750	-0.5652	217.56	7.46	-0.56	23.88	0.73	-1.08	407.	407.	407.
29.000	12.788	0.692	-0.6475	217.87	7.47	-0.61	20.44	0.71	-1.13	339.	339.	339.
30.000	10.973	0.604	-0.6869	218.30	7.49	-0.61	17.50	0.62	-0.89	281.	281.	281.

TABLE B-12. December Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1011.997	15.617	0.1498	253.71	9.66	0.01	1391.23	65.76	0.21	742.	742.	742.
0.135	993.719	15.068	0.1437	254.18	9.27	0.01	1363.34	61.44	0.20	743.	743.	743.
1.000	886.650	12.529	0.2011	262.45	8.17	-0.33	1176.71	41.72	0.30	798.	799.	799.
2.000	778.095	11.330	0.3018	260.44	6.57	-0.33	1040.61	27.72	0.48	799.	799.	799.
3.000	681.647	10.766	0.3895	254.91	5.92	-0.07	931.39	20.02	0.40	799.	799.	799.
4.000	594.794	10.431	0.4884	248.58	5.89	0.11	833.52	15.63	0.26	799.	799.	799.
5.000	517.741	10.171	0.5445	241.87	6.01	0.26	745.74	12.53	0.05	799.	799.	799.
6.000	448.576	10.158	0.5593	234.97	6.03	0.37	665.13	10.02	-0.15	796.	796.	796.
7.000	387.146	10.032	0.5653	228.12	5.76	0.37	591.26	8.61	-0.24	790.	790.	790.
8.000	332.456	9.474	0.6393	222.23	4.64	0.42	521.13	9.00	-0.29	787.	787.	787.
9.000	284.961	8.661	0.6635	218.65	3.60	0.26	454.07	13.12	-0.06	783.	783.	783.
10.000	243.684	7.397	0.7152	217.93	4.40	-0.05	389.76	16.11	0.48	781.	781.	781.
11.000	208.356	6.052	0.6998	218.75	5.29	-0.64	332.11	15.18	1.00	778.	778.	778.
12.000	178.307	4.969	0.5908	219.85	5.07	-0.89	282.73	11.65	1.24	775.	775.	775.
13.000	152.654	4.172	0.4696	220.29	4.64	-0.55	241.52	8.63	0.97	775.	775.	775.
14.000	130.715	3.589	0.3160	220.31	4.72	-0.42	206.77	6.85	0.81	772.	772.	772.
15.000	111.928	3.127	0.1572	220.24	5.01	-0.42	177.11	5.62	0.72	770.	770.	770.
16.000	95.776	2.846	0.0374	219.72	5.46	-0.39	151.91	4.90	0.60	681.	681.	681.
17.000	81.904	2.528	-0.1579	219.20	5.90	-0.39	130.21	4.04	0.46	671.	671.	671.
18.000	70.106	2.304	-0.3769	218.66	6.38	-0.43	111.73	3.36	0.35	664.	664.	664.
19.000	59.947	2.133	-0.4907	218.11	6.87	-0.40	95.78	2.82	0.29	652.	652.	652.
20.000	51.275	1.979	-0.6264	217.68	7.35	-0.38	82.08	2.41	0.18	646.	646.	646.
21.000	43.845	1.854	-0.6944	217.24	7.77	-0.34	70.32	2.06	0.03	622.	622.	622.
22.000	37.477	1.755	-0.7563	216.80	8.27	-0.35	60.23	1.81	-0.07	600.	600.	600.
23.000	32.080	1.583	-0.7646	216.55	8.67	-0.28	51.61	1.60	-0.19	582.	582.	582.
24.000	27.449	1.485	-0.8060	216.53	9.05	-0.21	44.16	1.46	-0.28	543.	543.	543.
25.000	23.506	1.311	-0.6954	216.29	9.22	-0.12	37.85	1.28	-0.29	513.	513.	513.
26.000	20.193	1.166	-0.7242	216.65	9.26	-0.10	32.46	1.16	-0.34	469.	469.	469.
27.000	17.306	1.060	-0.7282	216.95	9.40	-0.08	27.79	1.06	-0.42	405.	405.	405.
28.000	14.897	0.944	-0.8184	217.67	9.35	-0.06	23.83	0.97	-0.65	338.	338.	338.
29.000	12.723	0.886	-0.7971	217.27	9.83	0.05	20.38	0.90	-0.73	281.	281.	281.
30.000	11.025	0.679	-0.7420	218.19	9.24	0.13	17.60	0.72	-0.35	227.	227.	227.

TABLE B-13. Annual Thermodynamic Data, Fairbanks.

Z KM	MEAN P MB	S.D. P MB	SKEW P	MEAN T DEG K	S.D. T DEG K	SKEW T	MEAN D G/M3	S.D. D G/M3	SKEW D	NOBS P	NOBS T	NOBS D
0.000	1011.002	10.957	0.1978	272.52	15.75	-0.39	1294.56	82.73	0.69	9383.	9383.	9383.
0.135	993.971	10.619	0.0561	272.12	15.13	-0.37	1274.26	77.07	0.67	9401.	9401.	9401.
1.000	891.434	10.251	-0.4568	271.29	10.65	-0.42	1144.09	44.24	0.54	9737.	9753.	9751.
2.000	785.153	10.846	-0.3669	266.52	8.25	-0.29	1025.62	26.48	0.64	9747.	9749.	9747.
3.000	689.948	11.557	-0.2908	260.56	7.75	-0.16	922.06	18.82	0.51	9746.	9746.	9746.
4.000	603.882	12.178	-0.1962	254.35	7.94	-0.09	827.00	14.68	0.39	9746.	9746.	9746.
5.000	527.260	12.549	-0.1406	247.82	8.19	-0.02	741.23	11.73	0.25	9744.	9744.	9744.
6.000	458.529	12.948	-0.1007	240.97	8.25	0.07	662.96	9.26	0.05	9719.	9719.	9719.
7.000	397.227	13.019	-0.0675	234.00	7.97	0.21	591.38	7.78	-0.35	9668.	9668.	9668.
8.000	342.351	12.740	0.0370	227.39	7.10	0.43	524.44	8.55	-1.06	9605.	9605.	9605.
9.000	294.347	11.970	0.1032	222.40	5.52	0.55	461.01	12.92	-0.94	9561.	9561.	9561.
10.000	252.241	10.678	0.1979	220.36	4.69	-0.04	398.86	17.34	-0.29	9515.	9512.	9515.
11.000	216.083	9.182	0.2333	221.11	5.20	-0.42	340.68	17.58	0.32	9467.	9466.	9467.
12.000	185.260	7.817	0.1951	222.66	5.02	-0.83	290.01	14.16	0.67	9431.	9431.	9431.
13.000	158.938	6.734	0.1411	223.39	4.36	-0.83	247.92	10.97	0.51	9414.	9412.	9414.
14.000	136.406	5.859	0.0891	223.47	4.13	-0.87	212.67	9.06	0.35	9359.	9357.	9359.
15.000	117.055	5.115	0.0420	223.33	4.13	-0.99	182.61	7.70	0.27	9336.	9334.	9336.
16.000	100.607	4.465	-0.0783	223.22	4.19	-1.08	157.02	6.55	0.14	8944.	8944.	8946.
17.000	86.222	3.940	-0.0987	223.04	4.38	-1.15	134.67	5.55	0.10	8606.	8606.	8608.
18.000	73.993	3.461	-0.1575	222.95	4.57	-1.18	115.61	4.69	0.03	8568.	8569.	8571.
19.000	63.487	3.078	-0.2222	222.81	4.84	-1.20	99.25	3.99	-0.06	8472.	8470.	8474.
20.000	54.478	2.735	-0.2549	222.71	5.15	-1.18	85.20	3.42	-0.13	8419.	8419.	8421.
21.000	46.755	2.445	-0.3082	222.67	5.47	-1.14	73.13	2.95	-0.19	8285.	8286.	8287.
22.000	40.118	2.196	-0.3459	222.63	5.83	-1.11	62.76	2.56	-0.22	8135.	8136.	8137.
23.000	34.428	1.959	-0.3412	222.70	6.16	-1.04	53.83	2.21	-0.29	8026.	8027.	8026.
24.000	29.587	1.751	-0.3907	223.00	6.42	-1.01	46.20	1.93	-0.36	7785.	7785.	7785.
25.000	25.405	1.578	-0.3662	223.33	6.81	-0.96	39.60	1.67	-0.38	7521.	7521.	7521.
26.000	21.854	1.397	-0.3211	223.98	7.08	-0.85	33.97	1.44	-0.42	7282.	7282.	7281.
27.000	18.834	1.263	-0.3683	224.87	7.45	-0.80	29.16	1.26	-0.50	6658.	6657.	6657.
28.000	16.234	1.134	-0.3602	225.89	7.78	-0.75	25.01	1.11	-0.56	5986.	5986.	5985.
29.000	14.008	1.031	-0.3883	227.07	8.25	-0.76	21.47	0.99	-0.59	5287.	5287.	5286.
30.000	12.089	0.913	-0.2739	228.31	8.58	-0.70	18.42	0.85	-0.46	4560.	4560.	4559.

APPENDIX C

Fairbanks Moisture-Related Statistics Tables

Tables C-1 through C-13 provide moisture related statistics (monthly and annual, from surface to 30 km) for Fairbanks. They were prepared as described in Chapter 3.

TABLE C-1. January Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	1.470	1.225	1.4045	255.00	9.88	0.01	251.34	10.11	-0.07	713.	713.	713.
0.135	1.465	1.158	1.2819	255.51	9.48	-0.02	251.59	9.73	-0.11	715.	715.	715.
1.000	2.063	1.078	0.1817	263.66	8.69	-0.75	257.08	8.02	-0.84	775.	775.	775.
2.000	1.560	0.856	0.4255	262.01	7.03	-0.65	253.67	7.95	-0.78	773.	773.	773.
3.000	0.991	0.626	0.9760	256.47	6.28	-0.50	248.05	8.36	-0.68	772.	772.	772.
4.000	0.584	0.403	1.2004	250.16	6.10	-0.33	242.09	8.23	-0.48	766.	766.	766.
5.000	0.332	0.235	1.3091	244.38	5.35	0.13	236.25	8.06	-0.62	710.	711.	711.
6.000	0.201	0.131	1.2882	239.89	4.10	0.61	231.72	7.40	-1.03	500.	501.	501.
7.000	0.153	0.079	0.6895	237.39	2.83	1.17	229.64	6.27	-1.50	144.	144.	144.
8.000	0.133	0.036	-0.0046	236.40	2.21	0.55	229.52	2.60	-0.34	11.	11.	11.
9.000	0.000	0.000	0.0000	218.91	3.58	0.33	0.00	0.00	0.00	0.	0.	0.
10.000	0.000	0.000	0.0000	217.31	4.94	0.03	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	218.46	5.89	-0.37	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	219.98	5.31	-0.28	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	220.72	4.98	-0.10	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	220.85	5.00	-0.14	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	220.64	5.29	-0.17	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	220.47	5.59	-0.20	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	220.08	5.99	-0.23	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	219.99	6.34	-0.27	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	219.81	6.79	-0.36	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	219.89	7.18	-0.37	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	219.84	7.69	-0.35	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	219.86	8.26	-0.39	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	220.06	8.85	-0.35	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	220.52	9.26	-0.41	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	220.92	9.63	-0.46	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	221.68	9.69	-0.40	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	222.41	10.02	-0.34	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	223.30	10.35	-0.36	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	224.15	10.58	-0.41	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	224.83	10.45	-0.30	0.00	0.00	0.00	0.	0.	0.

TABLE C-2. February Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	1.392	1.315	1.3637	254.60	11.13	0.19	249.80	11.04	0.18	704.	704.	704.
0.135	1.370	1.253	1.3267	254.93	10.75	0.17	249.90	10.67	0.17	705.	705.	705.
1.000	1.700	1.161	0.9757	260.63	10.03	-0.23	253.95	9.00	-0.24	753.	753.	753.
2.000	1.295	0.879	1.1723	259.51	7.79	-0.14	250.91	8.63	-0.33	751.	751.	751.
3.000	0.821	0.626	1.5440	254.27	7.13	0.02	245.37	8.94	-0.29	745.	745.	745.
4.000	0.479	0.406	1.8740	248.17	6.87	0.22	239.39	8.76	-0.12	738.	738.	738.
5.000	0.284	0.257	2.2677	242.96	5.92	0.57	234.06	8.47	-0.26	646.	646.	646.
6.000	0.191	0.142	1.6859	239.82	4.58	0.73	230.85	7.63	-0.71	356.	356.	356.
7.000	0.150	0.092	0.5428	238.16	2.84	0.39	228.21	9.23	-1.82	113.	113.	113.
8.000	0.107	0.046	0.1094	235.38	1.44	0.32	226.98	4.31	-0.47	14.	14.	14.
9.000	0.000	0.000	0.0000	219.19	4.30	0.33	0.00	0.00	0.00	0.	0.	0.
10.000	0.000	0.000	0.0000	218.84	5.44	0.32	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	220.26	6.05	-0.40	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	221.59	5.84	-0.78	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	222.68	5.11	-0.66	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	222.90	5.21	-0.80	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	222.82	5.45	-0.94	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	222.74	5.73	-0.92	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	222.67	5.92	-1.02	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	222.87	5.94	-0.95	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	222.71	6.25	-0.77	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	222.65	6.54	-0.72	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	222.64	6.78	-0.60	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	222.50	7.08	-0.52	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	222.60	7.26	-0.35	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	222.90	7.54	-0.26	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	223.17	7.86	-0.20	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	223.67	8.29	-0.09	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	224.09	8.91	0.00	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	224.81	9.40	0.03	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	225.96	9.98	-0.09	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	226.51	10.33	-0.21	0.00	0.00	0.00	0.	0.	0.

TABLE C-3. March Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	1.987	1.206	0.8771	264.02	8.52	-0.32	256.44	8.07	-0.49	800.	800.	800.
0.135	1.925	1.135	0.8645	263.76	8.15	-0.32	256.20	7.76	-0.47	800.	800.	800.
1.000	1.963	0.962	0.6625	263.76	6.45	-0.39	257.05	6.49	-0.49	843.	843.	843.
2.000	1.403	0.728	0.5834	260.14	5.25	-0.18	252.78	7.07	-0.71	843.	843.	843.
3.000	0.817	0.506	1.2436	254.44	4.83	0.20	246.18	7.68	-0.65	835.	835.	835.
4.000	0.443	0.321	1.7810	248.10	5.00	0.35	239.39	7.59	-0.33	828.	828.	828.
5.000	0.240	0.191	2.1732	242.05	4.84	0.59	233.02	7.52	-0.35	786.	786.	786.
6.000	0.160	0.122	1.6552	238.66	3.82	0.71	229.07	7.78	-0.70	419.	419.	419.
7.000	0.139	0.079	0.4533	236.96	2.16	0.55	228.30	7.26	-1.45	97.	97.	97.
8.000	0.116	0.019	0.0485	233.91	0.52	1.20	228.40	1.54	-0.04	6.	6.	6.
9.000	0.000	0.000	0.0000	220.11	3.95	0.32	0.00	0.00	0.00	0.	0.	0.
10.000	0.000	0.000	0.0000	221.06	5.00	-0.14	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	223.20	5.05	-0.82	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	224.67	4.34	-0.91	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	225.32	3.73	-0.33	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	225.44	3.45	-0.20	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	225.47	3.24	-0.01	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	225.37	3.24	0.04	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	225.28	3.33	0.04	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	225.15	3.45	0.18	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	225.00	3.60	0.27	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	224.87	3.83	0.25	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	224.82	4.07	0.13	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	224.66	4.44	0.14	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	224.68	4.71	-0.03	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	224.71	5.03	-0.15	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	224.83	5.30	-0.11	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	225.07	5.71	-0.03	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	225.32	6.07	-0.02	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	225.81	6.39	-0.04	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	226.21	6.71	-0.15	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	226.61	7.05	-0.14	0.00	0.00	0.00	0.	0.	0.

TABLE C-4. April Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	3.297	1.457	0.4538	273.84	7.41	-0.58	263.65	6.46	-0.73	804.	804.	804.
0.135	3.145	1.377	0.4378	273.06	7.15	-0.59	263.08	6.37	-0.74	804.	804.	804.
1.000	2.482	1.037	0.3600	268.46	6.15	-0.70	260.23	5.93	-0.80	820.	820.	820.
2.000	1.711	0.852	0.3550	262.38	4.88	-0.43	254.97	7.83	-1.27	820.	820.	820.
3.000	1.002	0.639	1.1737	256.05	4.53	0.15	248.12	8.62	-0.90	819.	819.	819.
4.000	0.539	0.421	1.6191	249.66	4.86	0.47	240.82	8.78	-0.42	820.	820.	820.
5.000	0.284	0.243	2.2197	243.14	5.00	0.78	234.45	8.05	-0.29	806.	807.	807.
6.000	0.177	0.148	2.1468	239.07	4.48	1.01	229.72	8.19	-0.56	497.	497.	497.
7.000	0.149	0.113	0.8592	238.48	3.27	0.75	226.61	11.39	-1.16	129.	130.	130.
8.000	0.112	0.062	-0.1889	236.19	1.92	0.40	225.68	8.93	-1.68	25.	25.	25.
9.000	0.000	0.000	0.0000	220.48	3.83	0.33	0.00	0.00	0.00	0.	0.	0.
10.000	0.000	0.000	0.0000	221.27	4.04	-0.17	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	223.12	4.28	-0.72	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	224.29	3.80	-0.99	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	224.87	3.13	-0.58	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	224.90	2.98	-0.43	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	224.72	2.97	-0.34	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	224.50	3.14	-0.16	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	224.18	3.14	-0.09	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	223.98	3.11	0.00	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	223.68	3.15	0.20	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	223.43	3.07	0.35	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	223.14	3.10	0.43	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	222.87	3.22	0.33	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	222.66	3.34	0.38	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	222.57	3.46	0.39	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	222.60	3.54	0.30	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	222.82	3.70	0.30	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	223.39	3.75	0.34	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	224.10	3.93	0.33	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	224.90	4.10	0.27	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	225.88	4.16	0.32	0.00	0.00	0.00	0.	0.	0.

TABLE C-5. May Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP mb	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	5.640	2.024	0.8139	284.61	5.72	0.18	271.30	4.89	-0.11	833.	833.	833.
0.135	5.406	1.894	0.8009	283.60	5.51	0.18	270.76	4.77	-0.14	833.	833.	833.
1.000	4.153	1.367	0.6528	277.85	4.42	-0.02	267.32	4.51	-0.57	836.	836.	835.
2.000	3.031	1.067	0.3736	269.72	4.12	0.23	263.01	5.46	-1.67	835.	836.	836.
3.000	1.799	0.851	0.4829	262.36	4.08	0.06	255.84	7.23	-1.38	834.	834.	834.
4.000	0.889	0.550	1.0458	255.75	4.27	0.39	247.03	7.98	-0.74	832.	832.	832.
5.000	0.428	0.311	1.4986	248.94	4.57	0.26	238.88	7.95	-0.40	834.	835.	835.
6.000	0.225	0.166	1.5898	242.36	4.42	0.40	232.48	7.57	-0.44	759.	760.	760.
7.000	0.139	0.097	1.5166	238.25	3.24	0.73	227.53	8.53	-1.27	416.	417.	417.
8.000	0.103	0.061	0.7726	236.07	2.21	1.25	225.45	7.16	-1.13	61.	61.	61.
9.000	0.000	0.000	0.0000	222.04	3.42	0.55	0.00	0.00	0.00	2.	0.	2.
10.000	0.000	0.000	0.0000	221.00	3.98	0.17	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	223.01	4.68	-0.62	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	224.82	3.74	-1.07	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	225.31	2.87	-0.77	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	225.18	2.41	-0.56	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	224.87	2.21	-0.48	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	224.60	2.17	-0.32	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	224.48	2.16	-0.30	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	224.50	2.08	-0.25	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	224.47	2.06	-0.10	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	224.37	2.01	-0.18	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	224.37	2.06	-0.19	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	224.45	2.11	-0.26	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	224.62	2.19	-0.31	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	224.88	2.35	-0.35	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	225.47	2.47	-0.44	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	226.20	2.61	-0.50	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	227.24	2.74	-0.35	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	228.64	2.86	-0.29	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	230.26	3.00	-0.33	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	232.01	3.04	-0.30	0.00	0.00	0.00	0.	0.	0.

TABLE C-6. June Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	9.411	2.793	0.2732	290.21	5.13	0.32	278.67	4.45	-0.30	798.	798.	798.
0.135	8.986	2.606	0.2643	289.18	4.94	0.32	278.03	4.33	-0.30	800.	800.	800.
1.000	6.539	1.773	0.1792	283.15	4.00	0.03	273.61	4.02	-0.71	816.	816.	816.
2.000	4.714	1.342	-0.1456	275.16	3.51	0.04	269.11	4.36	-1.47	814.	814.	812.
3.000	2.880	1.142	-0.1887	268.08	3.19	0.04	261.91	6.86	-1.68	811.	811.	811.
4.000	1.473	0.819	0.3468	261.66	3.16	0.00	252.70	8.73	-1.04	810.	810.	810.
5.000	0.712	0.507	0.8966	255.06	3.37	0.07	243.49	9.81	-0.66	809.	809.	809.
6.000	0.368	0.283	1.3644	247.97	3.63	0.11	236.41	9.67	-0.68	794.	794.	794.
7.000	0.187	0.145	1.4068	240.75	3.60	0.49	229.66	9.64	-0.93	763.	763.	763.
8.000	0.126	0.077	1.1609	236.78	2.71	1.14	227.18	7.56	-1.37	253.	253.	253.
9.000	0.120	0.074	-0.0006	235.98	2.15	0.74	225.72	10.26	-1.54	12.	12.	12.
10.000	0.000	0.000	0.0000	221.25	3.83	0.54	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	222.20	4.80	-0.01	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	225.08	3.88	-0.80	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	226.05	2.72	-0.64	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	226.02	2.16	-0.44	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	225.84	1.88	-0.39	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	225.69	1.71	-0.34	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	225.75	1.65	-0.46	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	225.93	1.58	-0.16	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	226.17	1.47	-0.28	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	226.56	1.49	-0.23	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	226.99	1.55	-0.21	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	227.46	1.48	-0.01	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	227.97	1.49	0.03	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	228.54	1.55	-0.10	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	229.41	1.59	-0.09	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	230.52	1.69	-0.18	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	231.79	1.95	-0.62	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	233.45	1.93	-0.13	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	235.21	2.04	-0.38	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	237.10	2.20	-0.75	0.00	0.00	0.00	0.	0.	0.

TABLE C-7. July Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	12.111	2.808	0.0686	292.08	4.82	0.41	282.61	3.61	-0.64	814.	814.	813.
0.135	11.536	2.611	0.0407	291.11	4.62	0.40	281.90	3.50	-0.63	815.	815.	814.
1.000	8.266	1.839	0.1175	285.47	3.71	-0.16	277.06	3.35	-0.72	827.	827.	827.
2.000	5.777	1.424	-0.3533	277.78	3.26	-0.09	271.96	3.97	-1.90	827.	827.	826.
3.000	3.489	1.379	-0.4532	271.09	2.91	-0.15	264.26	7.30	-1.73	825.	825.	825.
4.000	1.833	1.010	0.1542	265.09	3.02	-0.20	255.24	8.93	-0.99	826.	826.	826.
5.000	0.965	0.653	0.7515	258.85	3.26	-0.18	247.12	9.55	-0.67	825.	825.	825.
6.000	0.506	0.384	1.1455	252.07	3.51	-0.18	239.74	9.66	-0.56	821.	821.	821.
7.000	0.253	0.203	1.4817	244.77	3.69	0.06	232.57	9.47	-0.60	814.	814.	814.
8.000	0.135	0.100	1.3493	238.41	3.04	0.86	226.90	9.00	-0.91	600.	600.	600.
9.000	0.099	0.067	0.6611	236.44	2.34	1.41	224.09	8.99	-1.05	85.	85.	85.
10.000	0.000	0.000	0.0000	223.10	3.23	0.63	0.00	0.00	0.00	3.	0.	3.
11.000	0.000	0.000	0.0000	221.03	4.75	0.90	0.00	0.00	0.00	2.	0.	2.
12.000	0.000	0.000	0.0000	223.73	4.82	-0.08	0.00	0.00	0.00	2.	0.	2.
13.000	0.000	0.000	0.0000	225.21	3.23	-1.00	0.00	0.00	0.00	2.	0.	2.
14.000	0.000	0.000	0.0000	225.53	2.49	-0.73	0.00	0.00	0.00	2.	0.	2.
15.000	0.000	0.000	0.0000	225.53	2.16	-0.63	0.00	0.00	0.00	2.	0.	2.
16.000	0.000	0.000	0.0000	225.62	1.88	-0.45	0.00	0.00	0.00	2.	0.	2.
17.000	0.000	0.000	0.0000	225.87	1.69	-0.20	0.00	0.00	0.00	2.	0.	2.
18.000	0.000	0.000	0.0000	226.14	1.62	0.31	0.00	0.00	0.00	2.	0.	2.
19.000	0.000	0.000	0.0000	226.49	1.48	0.17	0.00	0.00	0.00	2.	0.	2.
20.000	0.000	0.000	0.0000	226.92	1.41	0.12	0.00	0.00	0.00	2.	0.	2.
21.000	0.000	0.000	0.0000	227.39	1.43	-0.30	0.00	0.00	0.00	2.	0.	2.
22.000	0.000	0.000	0.0000	227.91	1.36	-0.11	0.00	0.00	0.00	2.	0.	2.
23.000	0.000	0.000	0.0000	228.45	1.38	-0.10	0.00	0.00	0.00	2.	0.	2.
24.000	0.000	0.000	0.0000	229.15	1.39	-0.11	0.00	0.00	0.00	2.	0.	2.
25.000	0.000	0.000	0.0000	230.09	1.40	-0.11	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	231.31	1.39	-0.27	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	232.67	1.51	-0.30	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	234.20	1.54	-0.44	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	235.79	1.61	-0.40	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	237.47	1.70	-0.32	0.00	0.00	0.00	0.	0.	0.

TABLE C-8. August Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	11.065	2.849	0.0052	288.97	5.18	0.10	281.21	3.97	-0.64	824.	824.	822.
0.135	10.524	2.688	-0.0147	288.10	5.03	0.10	280.47	3.93	-0.68	828.	828.	826.
1.000	7.532	1.916	0.0536	282.94	4.40	0.02	275.62	3.95	-1.07	848.	848.	848.
2.000	5.163	1.721	-0.2383	275.87	4.25	0.06	269.91	5.97	-1.95	845.	845.	845.
3.000	3.098	1.473	0.1014	269.81	4.12	0.05	262.28	8.20	-1.31	845.	845.	845.
4.000	1.713	1.032	0.5283	263.83	4.28	0.03	254.15	9.35	-0.88	846.	846.	846.
5.000	0.947	0.686	0.9653	257.53	4.67	0.03	246.65	9.83	-0.55	846.	846.	846.
6.000	0.491	0.407	1.2541	250.77	5.01	0.01	238.94	10.27	-0.47	838.	838.	838.
7.000	0.254	0.219	1.3869	243.97	4.99	0.22	232.08	10.22	-0.58	808.	808.	808.
8.000	0.152	0.119	1.1352	239.29	3.84	0.56	227.56	9.57	-0.76	513.	513.	513.
9.000	0.103	0.067	0.2647	236.75	2.17	0.69	224.12	9.62	-1.02	140.	140.	140.
10.000	0.070	0.051	-0.8326	234.02	0.37	-0.25	219.53	12.14	-0.95	6.	6.	6.
11.000	0.000	0.000	0.0000	222.12	4.49	0.18	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	223.47	4.98	-0.59	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	224.24	4.07	-0.87	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	224.28	3.32	-0.48	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	224.05	3.12	-0.61	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	224.00	2.81	-0.64	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	224.08	2.57	-0.69	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	224.34	2.28	-0.48	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	224.62	2.05	-0.29	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	224.79	1.95	-0.29	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	224.99	1.96	-0.23	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	225.26	1.99	-0.21	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	225.65	2.11	0.10	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	226.19	2.18	0.02	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	227.14	2.17	0.06	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	228.24	2.23	0.19	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	229.38	2.26	-0.05	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	230.64	2.33	-0.23	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	232.06	2.46	-0.40	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	233.59	2.55	-0.52	0.00	0.00	0.00	0.	0.	0.

TABLE C-9. September Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	7.503	2.354	0.4023	282.78	5.45	-0.01	275.37	4.68	-0.54	778.	778.	778.
0.135	7.142	2.224	0.3886	282.00	5.28	-0.03	274.69	4.62	-0.55	778.	778.	778.
1.000	5.359	1.604	0.2118	277.73	4.78	-0.58	270.76	4.47	-0.92	808.	808.	808.
2.000	3.611	1.389	-0.0295	271.39	4.43	-0.53	264.96	6.42	-1.54	808.	808.	808.
3.000	2.208	1.162	0.3139	265.43	4.20	-0.10	257.76	8.54	-1.10	806.	806.	806.
4.000	1.207	0.811	0.9168	259.30	4.35	0.03	249.76	9.51	-0.72	805.	805.	805.
5.000	0.645	0.529	1.2474	252.83	4.71	0.12	241.76	10.54	-0.47	803.	803.	803.
6.000	0.340	0.301	1.5000	246.07	4.99	0.22	234.85	10.49	-0.50	787.	787.	787.
7.000	0.195	0.167	1.4264	240.39	4.42	0.56	229.23	10.80	-0.87	640.	641.	641.
8.000	0.145	0.100	0.6069	237.96	2.88	0.50	227.30	9.73	-1.03	223.	223.	223.
9.000	0.119	0.053	-0.6771	235.41	1.46	0.47	227.25	7.45	-2.32	32.	32.	32.
10.000	0.000	0.000	0.0000	220.39	4.07	0.32	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	220.75	4.40	0.01	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	222.22	4.37	-0.93	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	222.88	3.41	-0.73	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	222.87	3.09	-0.56	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	222.70	2.88	-0.60	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	222.59	2.71	-0.44	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	222.47	2.55	-0.30	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	222.29	2.40	-0.13	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	222.06	2.35	-0.01	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	221.72	2.41	-0.02	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	221.46	2.51	-0.08	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	221.23	2.58	-0.11	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	221.19	2.73	-0.09	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	221.36	2.82	-0.10	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	221.78	3.00	-0.08	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	222.28	3.24	-0.10	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	223.01	3.45	-0.10	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	223.87	3.64	-0.09	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	224.97	3.91	-0.06	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	226.08	4.17	-0.11	0.00	0.00	0.00	0.	0.	0.

TABLE C-10. October Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	3.997	1.781	0.3268	271.00	7.35	-0.66	266.04	6.88	-0.91	812.	812.	812.
0.135	3.830	1.677	0.3165	270.54	7.10	-0.65	265.54	6.71	-0.91	818.	818.	818.
1.000	3.276	1.294	0.1567	268.75	6.22	-0.58	263.78	6.00	-1.07	826.	826.	826.
2.000	2.292	1.084	0.2604	264.94	5.32	-0.67	258.76	7.25	-1.07	822.	822.	822.
3.000	1.399	0.808	0.5251	259.44	4.91	-0.50	252.18	8.35	-0.83	819.	819.	819.
4.000	0.773	0.521	0.9229	253.06	4.98	-0.25	244.92	8.94	-0.71	820.	820.	820.
5.000	0.406	0.321	1.5400	246.54	4.90	0.10	237.61	9.19	-0.55	807.	807.	807.
6.000	0.214	0.176	1.6227	240.83	4.43	0.66	231.05	9.25	-0.68	678.	678.	678.
7.000	0.156	0.108	1.1270	238.54	3.30	0.83	228.59	8.64	-1.10	234.	234.	234.
8.000	0.120	0.062	-0.0900	236.18	2.11	1.02	226.81	7.82	-1.69	51.	51.	51.
9.000	0.000	0.000	0.0000	220.55	4.00	0.79	0.00	0.00	0.00	0.	0.	0.
10.000	0.000	0.000	0.0000	219.49	4.30	0.18	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	220.80	4.48	-0.62	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	221.75	4.15	-1.46	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	222.19	3.27	-0.93	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	222.19	2.97	-0.65	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	221.96	2.82	-0.65	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	221.68	2.77	-0.58	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	221.30	2.75	-0.47	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	220.82	2.82	-0.50	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	220.33	2.87	-0.62	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	219.74	3.04	-0.62	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	219.31	3.23	-0.48	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	218.90	3.41	-0.44	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	218.61	3.65	-0.43	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	218.46	3.80	-0.43	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	218.32	4.07	-0.42	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	218.19	4.24	-0.34	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	218.25	4.37	-0.41	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	218.49	4.41	-0.41	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	218.92	4.41	-0.29	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	219.33	4.46	-0.15	0.00	0.00	0.00	0.	0.	0.

TABLE C-11. November Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	1.889	1.344	1.1253	258.65	8.98	-0.17	255.07	9.27	-0.25	761.	761.	761.
0.135	1.858	1.274	1.0669	258.87	8.57	-0.17	255.09	8.91	-0.26	762.	762.	762.
1.000	2.232	1.118	0.6780	264.00	7.52	-0.19	258.56	6.59	-0.32	800.	800.	800.
2.000	1.672	0.890	0.6261	261.84	6.30	0.03	254.81	7.17	-0.59	799.	799.	799.
3.000	1.055	0.669	1.1374	256.33	6.01	0.25	248.98	7.94	-0.50	793.	794.	794.
4.000	0.596	0.462	1.8359	249.90	6.19	0.39	242.18	8.21	-0.24	794.	794.	794.
5.000	0.328	0.290	2.2210	243.84	6.06	0.58	235.67	8.56	-0.35	751.	753.	753.
6.000	0.224	0.191	2.1928	240.38	5.14	0.79	232.10	7.87	-0.25	467.	467.	467.
7.000	0.193	0.115	1.3899	238.92	3.40	0.53	231.49	7.23	-1.55	169	169.	169.
8.000	0.148	0.060	0.4014	236.14	1.80	0.79	229.87	5.15	-2.27	36.	36.	36.
9.000	0.000	0.000	0.0000	219.44	4.29	0.16	0.00	0.00	0.00	0.	0.	0.
10.000	0.000	0.000	0.0000	218.68	4.09	-0.06	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	219.21	5.07	-0.67	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	219.97	5.14	-1.15	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	220.45	4.55	-0.92	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	220.66	4.33	-0.62	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	220.62	4.46	-0.52	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	220.47	4.62	-0.53	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	220.13	4.73	-0.44	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	219.75	4.89	-0.36	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	219.21	5.13	-0.35	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	218.70	5.56	-0.37	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	218.37	5.95	-0.35	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	218.05	6.33	-0.32	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	217.73	6.69	-0.30	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	217.57	7.02	-0.30	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	217.16	7.40	-0.30	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	217.44	7.47	-0.43	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	217.44	7.48	-0.49	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	217.56	7.46	-0.56	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	217.87	7.47	-0.61	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	218.30	7.49	-0.61	0.00	0.00	0.00	0.	0.	0.

TABLE C-12. December Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	1.398	1.236	1.5143	253.85	9.78	0.03	250.46	10.39	0.03	742.	742.	742.
0.135	1.398	1.185	1.4497	254.32	9.39	0.02	250.74	9.99	0.02	743.	743.	743.
1.000	2.055	1.131	0.6064	262.69	8.28	-0.33	257.14	7.54	-0.45	799.	799.	799.
2.000	1.554	0.845	0.7309	260.63	6.65	-0.32	253.86	7.34	-0.62	798.	798.	798.
3.000	0.974	0.618	1.2217	255.07	5.96	-0.04	248.09	7.77	-0.52	795.	795.	795.
4.000	0.556	0.427	1.8496	248.76	5.83	0.20	241.60	7.81	-0.07	792.	792.	792.
5.000	0.316	0.263	2.0107	242.79	5.45	0.55	235.46	8.12	-0.44	734.	734.	734.
6.000	0.212	0.146	1.6364	239.63	4.33	0.58	232.24	6.93	-0.68	406.	406.	406.
7.000	0.157	0.082	0.4875	237.63	2.42	0.46	229.66	7.01	-1.80	127.	127.	127.
8.000	0.112	0.049	-1.5315	235.09	1.59	1.24	226.31	8.53	-2.58	9.	9.	9.
9.000	0.000	0.000	0.0000	218.65	3.60	0.26	0.00	0.00	0.00	0.	0.	0.
10.000	0.000	0.000	0.0000	217.93	4.40	-0.05	0.00	0.00	0.00	0.	0.	0.
11.000	0.000	0.000	0.0000	218.75	5.29	-0.64	0.00	0.00	0.00	0.	0.	0.
12.000	0.000	0.000	0.0000	219.85	5.07	-0.89	0.00	0.00	0.00	0.	0.	0.
13.000	0.000	0.000	0.0000	220.29	4.64	-0.55	0.00	0.00	0.00	0.	0.	0.
14.000	0.000	0.000	0.0000	220.31	4.72	-0.42	0.00	0.00	0.00	0.	0.	0.
15.000	0.000	0.000	0.0000	220.24	5.01	-0.42	0.00	0.00	0.00	0.	0.	0.
16.000	0.000	0.000	0.0000	219.72	5.46	-0.39	0.00	0.00	0.00	0.	0.	0.
17.000	0.000	0.000	0.0000	219.20	5.90	-0.39	0.00	0.00	0.00	0.	0.	0.
18.000	0.000	0.000	0.0000	218.66	6.38	-0.43	0.00	0.00	0.00	0.	0.	0.
19.000	0.000	0.000	0.0000	218.11	6.87	-0.40	0.00	0.00	0.00	0.	0.	0.
20.000	0.000	0.000	0.0000	217.68	7.35	-0.38	0.00	0.00	0.00	0.	0.	0.
21.000	0.000	0.000	0.0000	217.24	7.77	-0.34	0.00	0.00	0.00	0.	0.	0.
22.000	0.000	0.000	0.0000	216.80	8.27	-0.35	0.00	0.00	0.00	0.	0.	0.
23.000	0.000	0.000	0.0000	216.55	8.67	-0.28	0.00	0.00	0.00	0.	0.	0.
24.000	0.000	0.000	0.0000	216.53	9.05	-0.21	0.00	0.00	0.00	0.	0.	0.
25.000	0.000	0.000	0.0000	216.29	9.22	-0.12	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	216.65	9.26	-0.10	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	216.95	9.40	-0.08	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	217.67	9.35	-0.06	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	217.27	9.83	0.05	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	218.19	9.24	0.13	0.00	0.00	0.00	0.	0.	0.

TABLE C-13. Annual Moisture-Related Data, Fairbanks.

Z KM	VP MEAN MB	S.D. VP MB	SKEW VP	TV MEAN K	TV S.D. K	SKEW TV K	TD MEAN K	S.D. TD K	SKEW TD	NOBS VP	NOBS TV	NOBS TD
0.000	5.223	4.312	0.8277	273.07	16.14	-0.37	265.64	13.94	-0.47	9383.	9383.	9380.
0.135	5.003	4.078	0.8198	272.66	15.51	-0.35	265.30	13.53	-0.45	9401.	9401.	9398.
1.000	4.006	2.674	0.8056	271.76	10.92	-0.39	264.50	9.90	-0.43	9751.	9751.	9750.
2.000	2.840	1.925	0.8090	266.89	8.45	-0.26	260.02	9.87	-0.51	9735.	9736.	9733.
3.000	1.727	1.322	1.0440	260.84	7.86	-0.14	253.37	10.34	-0.40	9699.	9700.	9700.
4.000	0.933	0.810	1.4432	254.57	7.95	-0.05	245.88	10.26	-0.18	9677.	9677.	9677.
5.000	0.501	0.487	1.9160	248.51	7.74	0.12	238.91	10.07	-0.10	9357.	9362.	9362.
6.000	0.303	0.288	2.0735	244.27	6.50	0.27	234.03	9.57	-0.27	7322.	7324.	7324.
7.000	0.201	0.170	1.8038	241.18	4.68	0.53	230.23	9.67	-0.83	4454.	4457.	4457.
8.000	0.138	0.100	1.2650	238.09	3.32	0.89	227.18	8.86	-0.96	1802.	1802.	1802.
9.000	0.104	0.066	0.2893	236.45	2.18	1.00	224.58	9.20	-1.15	271.	271.	271.
10.000	0.103	0.108	2.1730	236.97	5.70	1.61	222.72	11.71	-0.79	9.	9.	9.
11.000	0.000	0.000	0.0000	221.11	5.20	-0.42	0.00	0.00	0.00	2.	0.	2.
12.000	0.000	0.000	0.0000	222.66	5.02	-0.83	0.00	0.00	0.00	2.	0.	2.
13.000	0.000	0.000	0.0000	223.39	4.36	-0.83	0.00	0.00	0.00	2.	0.	2.
14.000	0.000	0.000	0.0000	223.47	4.13	-0.87	0.00	0.00	0.00	2.	0.	2.
15.000	0.000	0.000	0.0000	223.33	4.13	-0.99	0.00	0.00	0.00	2.	0.	2.
16.000	0.000	0.000	0.0000	223.22	4.19	-1.08	0.00	0.00	0.00	2.	0.	2.
17.000	0.000	0.000	0.0000	223.04	4.38	-1.15	0.00	0.00	0.00	2.	0.	2.
18.000	0.000	0.000	0.0000	222.95	4.57	-1.18	0.00	0.00	0.00	2.	0.	2.
19.000	0.000	0.000	0.0000	222.81	4.84	-1.20	0.00	0.00	0.00	2.	0.	2.
20.000	0.000	0.000	0.0000	222.71	5.15	-1.18	0.00	0.00	0.00	2.	0.	2.
21.000	0.000	0.000	0.0000	222.67	5.47	-1.14	0.00	0.00	0.00	2.	0.	2.
22.000	0.000	0.000	0.0000	222.63	5.83	-1.11	0.00	0.00	0.00	2.	0.	2.
23.000	0.000	0.000	0.0000	222.70	6.16	-1.04	0.00	0.00	0.00	2.	0.	2.
24.000	0.000	0.000	0.0000	223.00	6.42	-1.01	0.00	0.00	0.00	2.	0.	2.
25.000	0.000	0.000	0.0000	223.33	6.81	-0.96	0.00	0.00	0.00	0.	0.	0.
26.000	0.000	0.000	0.0000	223.98	7.08	-0.85	0.00	0.00	0.00	0.	0.	0.
27.000	0.000	0.000	0.0000	224.87	7.45	-0.80	0.00	0.00	0.00	0.	0.	0.
28.000	0.000	0.000	0.0000	225.89	7.78	-0.75	0.00	0.00	0.00	0.	0.	0.
29.000	0.000	0.000	0.0000	227.07	8.25	-0.76	0.00	0.00	0.00	0.	0.	0.
30.000	0.000	0.000	0.0000	228.31	8.58	-0.70	0.00	0.00	0.00	0.	0.	0.

APPENDIX D

Fairbanks Hydrostatic Model Atmospheres

Tables D-1 through D-13 provide hydrostatic model atmospheres (monthly and annual) from 0 to 30 km over Fairbanks. They were prepared as described in Chapter 3.

TABLE D-1. January Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1013.3843	1384.4693	255.00
0.135	0.135	995.1876	1356.9038	255.51
1.000	1.002	888.1982	1173.6012	263.66
2.000	2.003	779.9111	1037.0083	262.01
3.000	3.005	683.7294	928.7527	256.47
4.000	4.007	597.0615	831.4812	250.16
5.000	5.008	520.0532	741.3695	244.38
6.000	6.010	451.0870	655.1087	239.89
7.000	7.011	389.7043	571.9127	237.39
8.000	8.013	334.8659	493.5006	236.40
9.000	9.015	287.2247	457.0956	218.91
10.000	10.016	245.5603	393.6717	217.31
11.000	11.018	209.8945	334.7194	218.46
12.000	12.020	179.6074	284.4455	219.98
13.000	13.021	153.8016	242.7639	220.72
14.000	14.023	131.7432	207.8162	220.85
15.000	15.024	112.8384	178.1677	220.64
16.000	16.026	96.6326	152.6967	220.47
17.000	17.028	82.6503	130.8321	220.08
18.000	18.029	70.8041	112.1294	219.99
19.000	19.031	60.6125	96.0644	219.81
20.000	20.033	51.9729	82.3446	219.89
21.000	21.034	44.5307	70.5686	219.84
22.000	22.036	38.1691	60.4825	219.86
23.000	23.037	32.7115	51.7875	220.06
24.000	24.039	28.0847	44.3681	220.52
25.000	25.041	24.0805	37.9739	220.92
26.000	26.042	20.7301	32.5789	221.68
27.000	27.044	17.8289	27.9274	222.41
28.000	28.046	15.3462	23.9421	223.30
29.000	29.047	13.2293	20.5619	224.15
30.000	30.049	11.4172	17.6917	224.83

TABLE D-2. February Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1013.9327	1387.4130	254.60
0.135	0.135	995.6458	1360.6506	254.93
1.000	1.002	887.7224	1186.6161	260.63
2.000	2.003	778.4919	1045.0868	259.51
3.000	3.005	681.6117	933.9147	254.27
4.000	4.007	594.4852	834.5306	248.17
5.000	5.008	517.2890	741.7429	242.96
6.000	6.010	447.9629	650.7380	239.82
7.000	7.011	386.5951	565.5204	238.16
8.000	8.013	332.0432	491.4433	235.38
9.000	9.015	284.6691	452.4604	219.19
10.000	10.016	243.5189	387.6792	218.84
11.000	11.018	208.4222	329.6663	220.26
12.000	12.020	178.5697	280.7438	221.59
13.000	13.021	153.1077	239.5399	222.68
14.000	14.023	131.3169	205.2419	222.90
15.000	15.024	112.6512	176.1311	222.82
16.000	16.026	96.7458	151.3176	222.74
17.000	17.028	82.9711	129.8117	222.67
18.000	18.029	71.2350	111.3539	222.87
19.000	19.031	61.1165	95.6061	222.71
20.000	20.033	52.4283	82.0368	222.65
21.000	21.034	44.9980	70.4131	222.64
22.000	22.036	38.5975	60.4335	222.50
23.000	23.037	33.1536	51.8868	222.60
24.000	24.039	28.4743	44.5051	222.90
25.000	25.041	24.4579	38.1805	223.17
26.000	26.042	21.0416	32.7735	223.67
27.000	27.044	18.0755	28.1016	224.09
28.000	28.046	15.5652	24.1209	224.81
29.000	29.047	13.4413	20.7240	225.96
30.000	30.049	11.5731	17.8000	226.51

TABLE D-3. March Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1010.6615	1333.6235	264.02
0.135	0.135	993.0964	1311.7346	263.76
1.000	1.002	887.6511	1172.4202	263.76
2.000	2.003	779.1208	1043.3976	260.14
3.000	3.005	682.3383	934.2857	254.44
4.000	4.007	595.1146	835.6752	248.10
5.000	5.008	517.8607	745.3534	242.05
6.000	6.010	448.6502	654.9253	238.66
7.000	7.011	387.1926	569.2588	236.96
8.000	8.013	332.5616	495.3108	233.91
9.000	9.015	285.2176	451.4248	220.11
10.000	10.016	244.2791	384.9737	221.06
11.000	11.018	209.4622	326.9474	223.20
12.000	12.020	179.8288	278.8486	224.67
13.000	13.021	154.4819	238.8528	225.32
14.000	14.023	132.7729	205.1784	225.44
15.000	15.024	114.0999	176.3017	225.47
16.000	16.026	98.0669	151.5979	225.37
17.000	17.028	84.2446	130.2778	225.28
18.000	18.029	72.3844	112.0040	225.15
19.000	19.031	62.2045	96.3157	225.00
20.000	20.033	53.4387	82.7905	224.87
21.000	21.034	45.9103	71.1434	224.82
22.000	22.036	39.4337	61.1494	224.66
23.000	23.037	33.8696	52.5174	224.68
24.000	24.039	29.1022	45.1188	224.71
25.000	25.041	25.0103	38.7546	224.83
26.000	26.042	21.4941	33.2705	225.07
27.000	27.044	18.4759	28.5673	225.32
28.000	28.046	15.8916	24.5182	225.81
29.000	29.047	13.6708	21.0543	226.21
30.000	30.049	11.7621	18.0825	226.61

TABLE D-4. April Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1010.9791	1286.1678	273.84
0.135	0.135	994.0019	1268.1785	273.06
1.000	1.002	890.9622	1156.2016	268.46
2.000	2.003	783.2585	1039.9965	262.38
3.000	3.005	686.7219	934.3429	256.05
4.000	4.007	599.5418	836.6258	249.66
5.000	5.008	522.0979	748.0964	243.14
6.000	6.010	452.7901	659.8129	239.07
7.000	7.011	391.0944	571.3285	238.48
8.000	8.013	336.1563	495.8377	236.19
9.000	9.015	288.4110	455.7140	220.48
10.000	10.016	247.0590	388.9933	221.27
11.000	11.018	211.8707	330.8213	223.12
12.000	12.020	181.8660	282.4922	224.29
13.000	13.021	156.1883	241.9777	224.87
14.000	14.023	134.1825	207.8555	224.90
15.000	15.024	115.2593	178.6836	224.72
16.000	16.026	99.0450	153.6985	224.50
17.000	17.028	85.0082	132.1078	224.18
18.000	18.029	72.9898	113.5303	223.98
19.000	19.031	62.6639	97.6007	223.68
20.000	20.033	53.7821	83.8585	223.43
21.000	21.034	46.1593	72.0665	223.14
22.000	22.036	39.5979	61.8969	222.87
23.000	23.037	33.9697	53.1494	222.66
24.000	24.039	29.1508	45.6284	222.57
25.000	25.041	24.9978	39.1224	222.60
26.000	26.042	21.4428	33.5258	222.82
27.000	27.044	18.4116	28.7139	223.39
28.000	28.046	15.8135	24.5833	224.10
29.000	29.047	13.5700	21.0212	224.90
30.000	30.049	11.6463	17.9629	225.88

TABLE D-5. May Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1009.2527	1235.4040	284.61
0.135	0.135	992.9418	1219.7548	283.60
1.000	1.002	893.3899	1120.1856	277.85
2.000	2.003	788.5329	1018.5197	269.72
3.000	3.005	693.7990	921.2952	262.36
4.000	4.007	607.7342	827.8565	255.75
5.000	5.008	530.8852	742.9531	248.94
6.000	6.010	461.9448	664.0324	242.36
7.000	7.011	400.4438	585.5550	238.25
8.000	8.013	345.1141	509.3131	236.07
9.000	9.015	296.7189	439.4039	235.25
10.000	10.016	254.2475	400.8034	221.00
11.000	11.018	218.0241	340.5999	223.01
12.000	12.020	187.1577	290.0227	224.82
13.000	13.021	160.7961	248.6305	225.31
14.000	14.023	138.1505	213.7330	225.18
15.000	15.024	118.6833	183.8688	224.87
16.000	16.026	101.9779	158.1785	224.60
17.000	17.028	87.5803	135.9232	224.48
18.000	18.029	75.2145	116.7202	224.50
19.000	19.031	64.6132	100.2812	224.47
20.000	20.033	55.4882	86.1564	224.37
21.000	21.034	47.6614	74.0061	224.37
22.000	22.036	40.9295	63.5302	224.45
23.000	23.037	35.1531	54.5219	224.62
24.000	24.039	30.2013	46.7873	224.88
25.000	25.041	25.9628	40.1163	225.47
26.000	26.042	22.3166	34.3708	226.20
27.000	27.044	19.1979	29.4330	227.24
28.000	28.046	16.5405	25.2026	228.64
29.000	29.047	14.2571	21.5712	230.26
30.000	30.049	12.2917	18.4571	232.01

TABLE D-6. June Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1010.0951	1212.5786	290.21
0.135	0.135	994.0666	1197.5972	289.18
1.000	1.002	896.1637	1102.6232	283.15
2.000	2.003	792.9314	1003.9403	275.16
3.000	3.005	699.5073	909.0518	268.08
4.000	4.007	614.5471	818.2173	261.66
5.000	5.008	538.4703	735.4786	255.06
6.000	6.010	470.1330	660.5014	247.97
7.000	7.011	408.8911	591.7079	240.75
8.000	8.013	353.8048	520.5743	236.78
9.000	9.015	304.9697	450.2269	235.98
10.000	10.016	261.7072	412.0840	221.25
11.000	11.018	224.4024	351.8380	222.20
12.000	12.020	192.6124	298.1325	225.08
13.000	13.021	165.5363	255.1178	226.05
14.000	14.023	142.3240	219.3797	226.02
15.000	15.024	122.3450	188.7289	225.84
16.000	16.026	105.1662	162.3394	225.69
17.000	17.028	90.4190	139.5362	225.75
18.000	18.029	77.7240	119.8527	225.93
19.000	19.031	66.8306	102.9421	226.17
20.000	20.033	57.4741	88.3792	226.56
21.000	21.034	49.4417	75.8838	226.99
22.000	22.036	42.5566	65.1802	227.46
23.000	23.037	36.6278	55.9750	227.97
24.000	24.039	31.5274	48.0605	228.54
25.000	25.041	27.1737	41.2656	229.41
26.000	26.042	23.4244	35.4007	230.52
27.000	27.044	20.2073	30.3720	231.79
28.000	28.046	17.4633	26.0611	233.45
29.000	29.047	15.1077	22.3770	235.21
30.000	30.049	13.0655	19.1980	237.10

TABLE D-7. July Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1011.7640	1206.7875	292.08
0.135	0.135	995.8430	1191.7473	291.11
1.000	1.002	898.4469	1096.4435	285.47
2.000	2.003	795.7958	998.0494	277.78
3.000	3.005	702.8946	903.3143	271.09
4.000	4.007	618.5380	812.8761	265.09
5.000	5.008	542.9654	730.7735	258.85
6.000	6.010	475.1383	656.6935	252.07
7.000	7.011	414.1008	589.4040	244.77
8.000	8.013	359.3143	525.0562	238.41
9.000	9.015	310.4614	457.4436	236.44
10.000	10.016	266.9112	382.8587	242.88
11.000	11.018	228.9267	319.9193	249.29
12.000	12.020	196.3186	271.8424	251.59
13.000	13.021	168.6277	231.3607	253.92
14.000	14.023	144.9100	196.9886	256.28
15.000	15.024	124.5515	167.7297	258.70
16.000	16.026	107.0067	142.7207	261.21
17.000	17.028	92.0081	121.4931	263.83
18.000	18.029	79.1014	103.3436	266.66
19.000	19.031	68.0105	87.8326	269.76
20.000	20.033	58.5127	74.5960	273.27
21.000	21.034	50.3410	65.1376	269.24
22.000	22.036	43.3419	57.5519	262.36
23.000	23.037	37.3210	51.2739	253.58
24.000	24.039	32.1326	45.6712	245.11
25.000	25.041	27.7053	41.9490	230.09
26.000	26.042	23.8958	35.9897	231.31
27.000	27.044	20.6157	30.8684	232.67
28.000	28.046	17.8317	26.5250	234.20
29.000	29.047	15.4231	22.7883	235.79
30.000	30.049	13.3479	19.5823	237.47

TABLE D-8. August Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1012.2092	1220.3044	288.97
0.135	0.135	996.1157	1204.5677	288.10
1.000	1.002	897.8435	1105.5239	282.94
2.000	2.003	794.4451	1003.2849	275.87
3.000	3.005	701.1846	905.3984	269.81
4.000	4.007	616.6163	814.2358	263.83
5.000	5.008	540.9338	731.7805	257.53
6.000	6.010	473.0127	657.1367	250.77
7.000	7.011	412.0453	588.3930	243.97
8.000	8.013	357.2563	520.1321	239.29
9.000	9.015	308.5975	454.1084	236.75
10.000	10.016	265.3105	394.9598	234.02
11.000	11.018	227.6378	357.0358	222.12
12.000	12.020	195.2819	304.4446	223.47
13.000	13.021	167.6081	260.3956	224.24
14.000	14.023	143.9356	223.5788	224.28
15.000	15.024	123.5810	192.1639	224.05
16.000	16.026	106.1090	165.0283	224.00
17.000	17.028	91.1175	141.6632	224.08
18.000	18.029	78.2230	121.4720	224.34
19.000	19.031	67.1824	104.1995	224.62
20.000	20.033	57.7092	89.4382	224.79
21.000	21.034	49.5814	76.7735	224.99
22.000	22.036	42.6014	65.8862	225.26
23.000	23.037	36.6142	56.5281	225.65
24.000	24.039	31.4745	48.4771	226.19
25.000	25.041	27.0883	41.5470	227.14
26.000	26.042	23.3265	35.6052	228.24
27.000	27.044	20.0887	30.5112	229.38
28.000	28.046	17.3343	26.1833	230.64
29.000	29.047	14.9727	22.4780	232.06
30.000	30.049	12.9280	19.2816	233.59

TABLE D-9. September Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1010.3460	1244.7571	282.78
0.135	0.135	993.9272	1227.8813	282.00
1.000	1.002	894.0790	1121.5212	277.73
2.000	2.003	789.3837	1013.3208	271.39
3.000	3.005	695.2757	912.5775	265.43
4.000	4.007	610.0055	819.5807	259.30
5.000	5.008	533.9405	735.7447	252.83
6.000	6.010	465.6579	659.2856	246.07
7.000	7.011	404.5969	586.3665	240.39
8.000	8.013	349.6138	511.8544	237.96
9.000	9.015	301.2766	445.8554	235.41
10.000	10.016	258.3238	408.3408	220.39
11.000	11.018	221.2736	349.2098	220.75
12.000	12.020	189.6521	297.3249	222.22
13.000	13.021	162.6553	254.2428	222.88
14.000	14.023	139.5405	218.1218	222.87
15.000	15.024	119.6895	187.2352	222.70
16.000	16.026	102.6771	160.7015	222.59
17.000	17.028	88.0649	137.9081	222.47
18.000	18.029	75.5243	118.3656	222.29
19.000	19.031	64.7675	101.6123	222.06
20.000	20.033	55.5222	87.2400	221.72
21.000	21.034	47.5993	74.8785	221.46
22.000	22.036	40.7860	64.2291	221.23
23.000	23.037	34.9525	55.0513	221.19
24.000	24.039	29.9621	47.1547	221.36
25.000	25.041	25.6819	40.3426	221.78
26.000	26.042	22.0183	34.5098	222.28
27.000	27.044	18.9027	29.5294	223.01
28.000	28.046	16.2338	25.2628	223.87
29.000	29.047	13.9645	21.6255	224.97
30.000	30.049	11.9994	18.4910	226.08

TABLE D-10. October Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1007.2793	1294.9158	271.00
0.135	0.135	990.2618	1275.1728	270.54
1.000	1.002	887.2605	1150.1735	268.75
2.000	2.003	780.5688	1026.4079	264.94
3.000	3.005	685.3424	920.3124	259.44
4.000	4.007	599.3663	825.1302	253.06
5.000	5.008	522.9397	738.9610	246.54
6.000	6.010	454.3366	657.2510	240.83
7.000	7.011	393.2238	574.3005	238.54
8.000	8.013	338.4205	499.1886	236.18
9.000	9.015	290.6487	459.1096	220.55
10.000	10.016	248.8417	394.9673	219.49
11.000	11.018	213.1084	336.2466	220.80
12.000	12.020	182.6419	286.9418	221.75
13.000	13.021	156.5762	245.5083	222.19
14.000	14.023	134.2557	210.5026	222.19
15.000	15.024	115.1124	180.6804	221.96
16.000	16.026	98.7326	155.1644	221.68
17.000	17.028	84.5873	133.1632	221.30
18.000	18.029	72.4829	114.3569	220.82
19.000	19.031	62.0912	98.1773	220.33
20.000	20.033	53.1679	84.2943	219.74
21.000	21.034	45.4959	72.2712	219.31
22.000	22.036	38.9296	61.9568	218.90
23.000	23.037	33.3038	53.0744	218.61
24.000	24.039	28.5075	45.4619	218.46
25.000	25.041	24.3899	38.9201	218.32
26.000	26.042	20.8703	33.3230	218.19
27.000	27.044	17.8731	28.5303	218.25
28.000	28.046	15.3104	24.4130	218.49
29.000	29.047	13.1146	20.8703	218.92
30.000	30.049	11.2232	17.8271	219.33

TABLE D-11. November Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1010.8623	1361.5701	258.65
0.135	0.135	992.9455	1336.2660	258.87
1.000	1.002	886.9800	1170.4789	264.00
2.000	2.003	778.8936	1036.3352	261.84
3.000	3.005	682.7633	927.9755	256.33
4.000	4.007	596.1303	831.0719	249.90
5.000	5.008	519.2809	741.9262	243.84
6.000	6.010	450.3540	652.7119	240.38
7.000	7.011	388.9851	567.1924	238.92
8.000	8.013	334.3481	493.2724	236.14
9.000	9.015	286.7870	455.3036	219.44
10.000	10.016	245.3882	390.9397	218.68
11.000	11.018	209.8732	333.5408	219.21
12.000	12.020	179.6706	284.5529	219.97
13.000	13.021	153.8451	243.1292	220.45
14.000	14.023	131.7590	208.0219	220.66
15.000	15.024	112.8515	178.2044	220.62
16.000	16.026	96.6680	152.7530	220.47
17.000	17.028	82.7194	130.9148	220.13
18.000	18.029	70.8287	112.2878	219.75
19.000	19.031	60.5996	96.3098	219.21
20.000	20.033	51.8587	82.6106	218.70
21.000	21.034	44.3633	70.7777	218.37
22.000	22.036	37.9376	60.6151	218.05
23.000	23.037	32.4456	51.9161	217.73
24.000	24.039	27.7529	44.4389	217.57
25.000	25.041	23.7037	38.0272	217.16
26.000	26.042	20.3266	32.5671	217.44
27.000	27.044	17.4090	27.8922	217.44
28.000	28.046	14.9171	23.8865	217.56
29.000	29.047	12.7856	20.4443	217.87
30.000	30.049	10.9695	17.5062	218.30

TABLE D-12. December Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1011.9973	1388.8913	253.85
0.135	0.135	993.7006	1361.2292	254.32
1.000	1.002	886.5484	1175.7684	262.69
2.000	2.003	777.9931	1039.9540	260.63
3.000	3.005	681.5564	930.8890	255.07
4.000	4.007	594.7137	832.8766	248.76
5.000	5.008	517.6691	742.8245	242.79
6.000	6.010	448.5123	652.0547	239.63
7.000	7.011	387.0910	567.4957	237.63
8.000	8.013	332.4079	492.6051	235.09
9.000	9.015	284.9185	453.9789	218.65
10.000	10.016	243.6461	389.4849	217.93
11.000	11.018	208.3233	331.7729	218.75
12.000	12.020	178.2789	282.5051	219.85
13.000	13.021	152.6299	241.3772	220.29
14.000	14.023	130.6945	206.6699	220.31
15.000	15.024	111.9103	177.0210	220.24
16.000	16.026	95.7607	151.8361	219.72
17.000	17.028	81.8913	130.1508	219.20
18.000	18.029	70.0946	111.6770	218.66
19.000	19.031	59.9380	95.7389	218.11
20.000	20.033	51.2666	82.0489	217.68
21.000	21.034	43.8381	70.3011	217.24
22.000	22.036	37.4711	60.2145	216.80
23.000	23.037	32.0753	51.6029	216.55
24.000	24.039	27.4448	44.1571	216.53
25.000	25.041	23.5025	37.8554	216.29
26.000	26.042	20.1893	32.4649	216.65
27.000	27.044	17.3032	27.7853	216.95
28.000	28.046	14.8944	23.8388	217.67
29.000	29.047	12.7215	20.3981	217.27
30.000	30.049	11.0216	17.5982	218.19

TABLE D-13. Annual Hydrostatic Model Atmosphere, Fairbanks.

Z KM	GEO. HT KM	PRESS MB	D G/M^3	TV K
0.000	0.000	1011.0024	1289.8421	273.07
0.135	0.135	993.9547	1269.9982	272.66
1.000	1.002	891.3373	1142.6593	271.76
2.000	2.003	785.0530	1024.7670	266.89
3.000	3.005	689.8590	921.3890	260.84
4.000	4.007	603.8018	826.3032	254.57
5.000	5.008	527.1887	739.0457	248.51
6.000	6.010	458.4648	653.8734	244.27
7.000	7.011	397.1710	573.7048	241.18
8.000	8.013	342.3021	500.8720	238.09
9.000	9.015	294.3047	433.6240	236.45
10.000	10.016	252.2048	370.7741	236.97
11.000	11.018	216.0526	301.9281	249.29
12.000	12.020	185.2345	256.4941	251.59
13.000	13.021	158.9160	218.0361	253.92
14.000	14.023	136.3881	185.4041	256.28
15.000	15.024	117.0392	157.6132	258.70
16.000	16.026	100.5935	134.1671	261.21
17.000	17.028	86.2112	113.8384	263.83
18.000	18.029	73.9839	96.6578	266.66
19.000	19.031	63.4793	81.9808	269.76
20.000	20.033	54.4712	69.4437	273.27
21.000	21.034	46.7487	60.4894	269.24
22.000	22.036	40.1126	53.2638	262.36
23.000	23.037	34.4237	47.2933	253.58
24.000	24.039	29.5833	42.0478	245.11
25.000	25.041	25.4013	39.6241	223.33
26.000	26.042	21.8510	33.9877	223.98
27.000	27.044	18.8309	29.1744	224.87
28.000	28.046	16.2313	25.0330	225.89
29.000	29.047	14.0057	21.4885	227.07
30.000	30.049	12.0851	18.4408	228.31

APPENDIX E

Wind Statistics Derivable from Appendix A Tables

Appendix E gives a few graphic examples of certain wind statistics that can be derived from basic data in Appendix A. These examples should help RRA users understand the functional relationships of the probability wind models and develop an appreciation for the powerful properties of the bivariate normal probability distribution function. Only a few of the many options in deriving wind statistics are illustrated here.

All illustrations for this appendix were derived for the five wind component statistical parameters from Table A-1 (January) and Table A-7 (July) for nine selected altitudes; these are: 2, 4, 8, 12, 16, 20, 24, 28, and 30 km. Descriptions of Tables E-1 and E-2 and Figures E-1 through E-72 follow:

Wind Speed (Tables E-1 and E-2)

The five wind components from Appendix A are used as inputs to the generalized Rayleigh probability density function (equation 29), then integrated as indicated by equation 30 to obtain the probability distribution function for wind speed. The derived distribution functions for wind speed are shown in Tables E-1 and E-2 on the normal probability scale.

Frequency of Wind Direction (Figures E-1 through E-18)

The derived frequencies for wind direction shown in Figures E-1 through E-18 were obtained using the five wind component parameters from Tables A-1 and A-7 as input values in equation 35. The limits of integration (performed numerically) are over the 22.5-degree interval for each of the 16 compass points. The graphs give the percentage frequency that the wind will blow from the direction intervals.

Mean Wind Components and 80th Interpercentile Range of Wind Components (Figures E-19 through E-36)

Wind component means with respect to any orthogonal axis are obtained by using the zonal and meridional mean wind components in equations 44 and 45. These component means form the circle shown in Figures E-19 through E-36. The zonal and meridional wind component variances and correlation coefficients are then used in equations 46 and 47 to obtain the variances with respect to any orthogonal axis. These rotated component variances and the rotated component means are used in equation 8 to obtain the 80th interpercentile range of wind components, as shown in Figures E-19 through E-36.

Probability Ellipses (Figures E-37 through E-54)

Using the five wind component parameters from Tables A-1 and A-7, and $p = 0.50$, $p = 0.95$, and $p = 0.99$ as input values to equation 13, the wind probability ellipses shown in Figures E-37 through E-54 were produced with computer graphics, using the standard meteorological coordinate system explained in Chapter 1. Statistical inferences are, for example, that 50 percent of the wind vectors lie within the smaller ellipse, and that 99 percent lie within the outer ellipse.

Conditional Wind Speed Given Wind Direction (Figures E-55 through E-72)

The five wind component parameters from Tables A-1 and A-7 were used to evaluate the conditional probability distribution function, equation 41. Interpolations of the conditional function are made to obtain the 5th, 15th, 50th (median), 85th, 95th, and 99th conditional percentile values of wind speed, given wind directions, are as shown in Figures E-55 through E-72. The conditional mean wind speed, given wind direction, is obtained from equation 40. The conditional mode (most probable) wind speed given wind direction is obtained from equation 38. The conditional mean wind speed and the conditional wind speed modal value, given the wind direction, are also shown. For some figures, conditional wind speed values are invalid for a given wind direction near 270 degrees (from the west); this is caused by the lack of computational precision in evaluating equations 40 and 41 when arguments for the Gaussian probability distribution have large negative values; i.e., when the coefficients (b/a) become less than -4 in these equations.

TABLE E-1. Derived (Rayleigh) Percentiles for Windspeed (M/S), January.

ALTITUDE (KM)

PERCENTILE	2 KM	4 KM	8 KM	12 KM	16 KM	20 KM	24 KM	28 KM	30 KM
0.010	1.051	1.401	2.452	2.545	3.692	3.981	4.143	4.421	4.592
0.025	1.662	2.222	3.886	4.010	5.681	6.221	6.551	6.956	7.251
0.050	2.369	3.171	5.528	5.637	7.775	8.686	9.266	9.865	10.290
0.100	3.399	4.548	7.929	7.864	10.500	12.034	13.087	14.025	14.623
0.150	4.222	5.653	9.841	9.543	12.457	14.517	16.027	17.268	18.015
0.200	4.947	6.622	11.529	10.948	14.051	16.581	18.518	20.063	20.942
0.300	6.261	8.376	14.558	13.360	16.704	20.076	22.843	24.971	26.104
0.400	7.498	10.028	17.395	15.498	19.030	23.158	26.727	29.457	30.825
0.500	8.742	11.689	20.227	17.544	21.222	26.093	30.458	33.812	35.426
0.600	10.063	13.446	23.209	19.629	23.441	29.062	34.272	38.290	40.174
0.700	11.550	15.421	26.539	21.892	25.838	32.285	38.422	43.198	45.388
0.800	13.381	17.838	30.576	24.568	28.669	36.093	43.329	49.039	51.603
0.850	14.550	19.376	33.124	26.227	30.413	38.439	46.370	52.668	55.480
0.900	16.067	21.355	36.385	28.322	32.617	41.402	50.202	57.243	60.394
0.950	18.399	24.374	41.330	31.476	35.900	45.826	55.923	64.104	67.739
0.975	20.502	27.070	45.724	34.236	38.793	49.691	60.934	70.140	74.268
0.990	23.054	30.271	50.867	37.521	42.128	54.201	66.775	77.256	81.885

TABLE E-2. Derived (Rayleigh) Percentiles for Windspeed (M/S), July.

ALTITUDE (KM)

PERCENTILE	2 KM	4 KM	8 KM	12 KM	16 KM	20 KM	24 KM	28 KM	30 KM
0.010	0.694	0.893	1.490	1.207	0.558	0.397	1.149	2.951	3.445
0.025	1.100	1.414	2.360	1.921	0.884	0.633	1.695	3.662	4.210
0.050	1.566	2.014	3.362	2.733	1.261	0.901	2.220	4.287	4.883
0.100	2.251	2.891	4.821	3.919	1.808	1.291	2.864	5.027	5.678
0.150	2.804	3.598	5.985	4.870	2.245	1.606	3.316	5.531	6.223
0.200	3.294	4.218	7.012	5.706	2.631	1.883	3.680	5.935	6.659
0.300	4.186	5.346	8.868	7.217	3.328	2.384	4.277	6.592	7.374
0.400	5.041	6.413	10.618	8.642	3.986	2.857	4.794	7.155	7.987
0.500	5.914	7.491	12.374	10.074	4.648	3.333	5.281	7.685	8.564
0.600	6.860	8.640	14.230	11.590	5.349	3.839	5.771	8.214	9.143
0.700	7.948	9.946	16.321	13.296	6.139	4.409	6.297	8.783	9.766
0.800	9.320	11.566	18.879	15.389	7.111	5.110	6.917	9.451	10.500
0.850	10.210	12.606	20.504	16.717	7.731	5.556	7.298	9.862	10.951
0.900	11.385	13.966	22.600	18.436	8.530	6.134	7.777	10.376	11.519
0.950	13.208	16.073	25.806	21.062	9.762	7.018	8.489	11.143	12.366
0.975	14.848	17.970	28.666	23.427	10.869	7.808	9.115	11.816	13.109
0.990	16.810	20.287	32.111	26.231	12.202	8.750	9.856	12.613	13.989

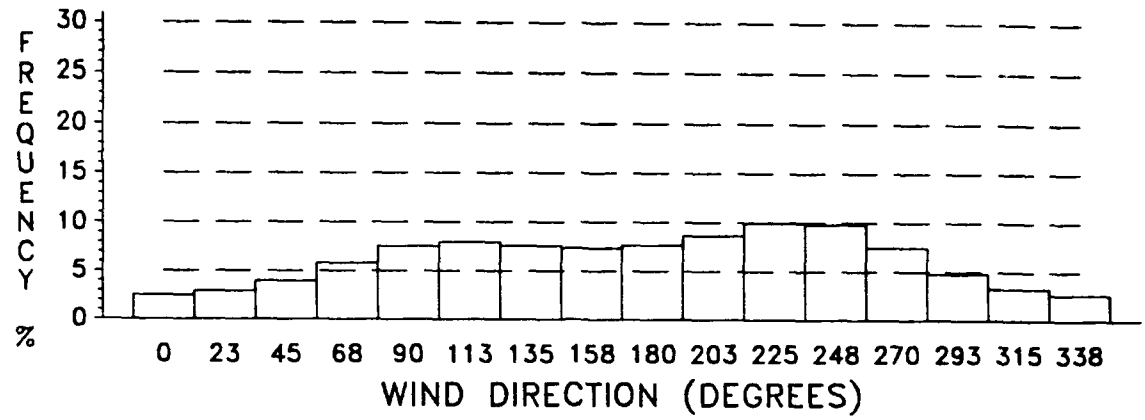

Figure E-1. Wind Direction Frequency, January, 2 KM.

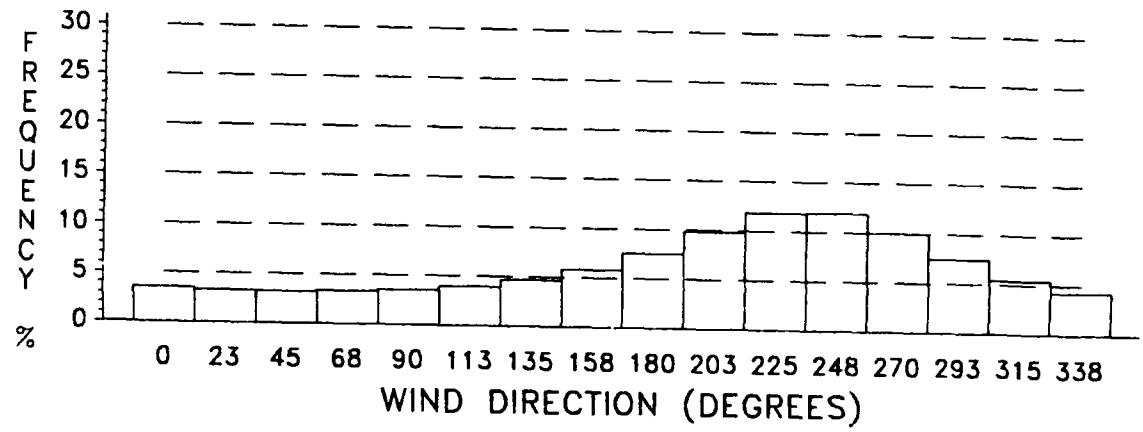

Figure E-2. Wind Direction Frequency, January, 4 KM.

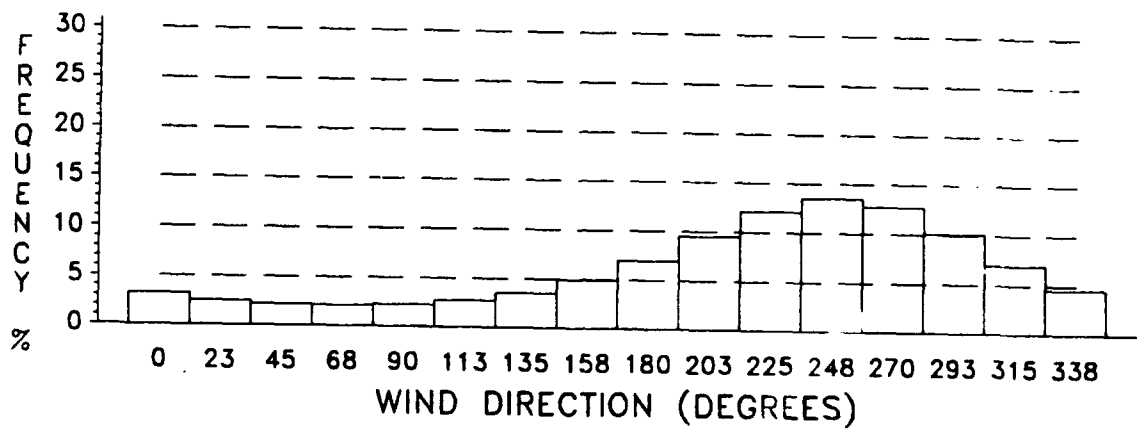

Figure E-3. Wind Direction Frequency, January, 8 KM.

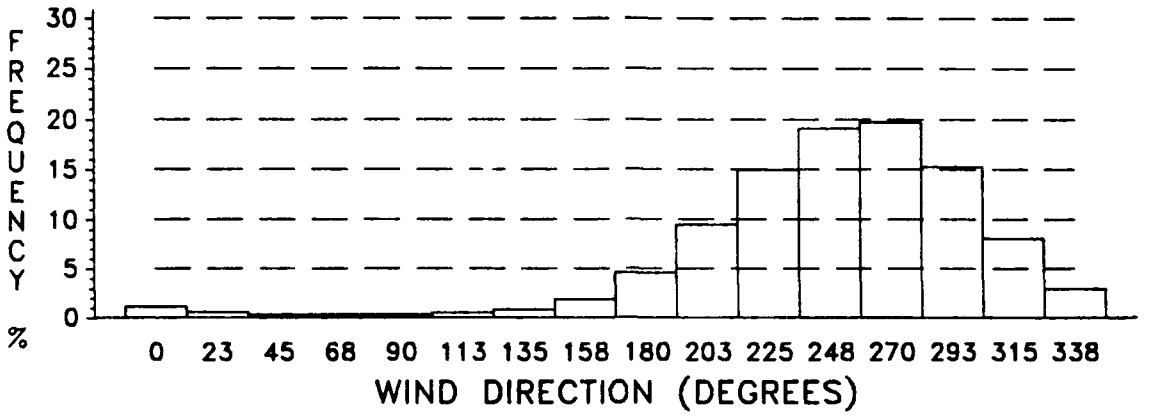

Figure E-4. Wind Direction Frequency, January, 12 KM.

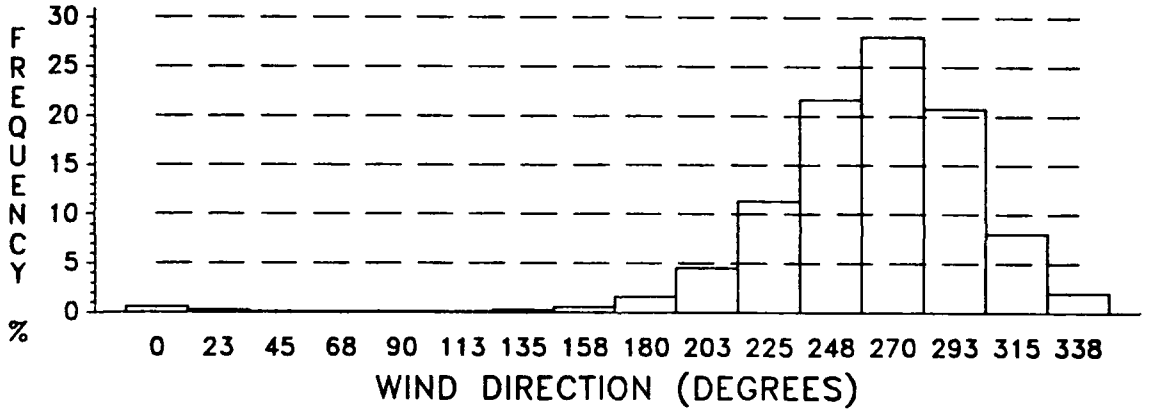

Figure E-5. Wind Direction Frequency, January, 16 KM.

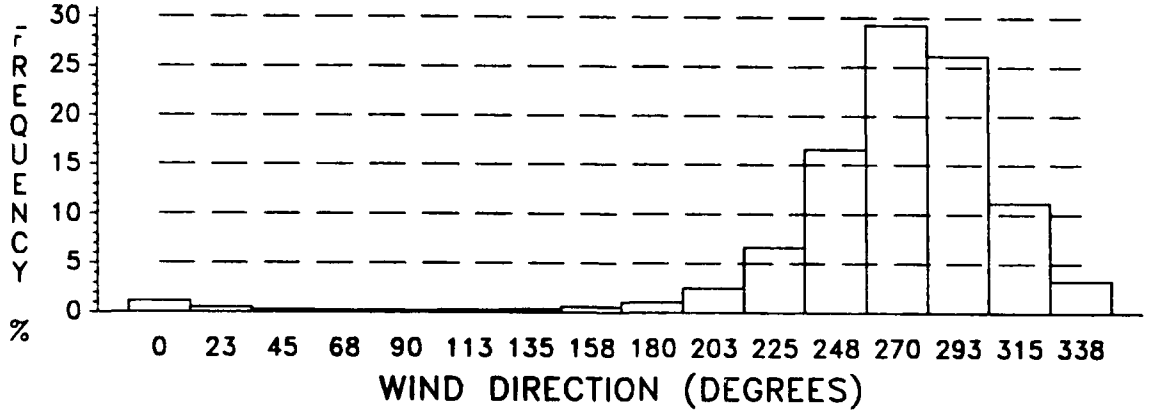

Figure E-6. Wind Direction Frequency, January, 20 KM.

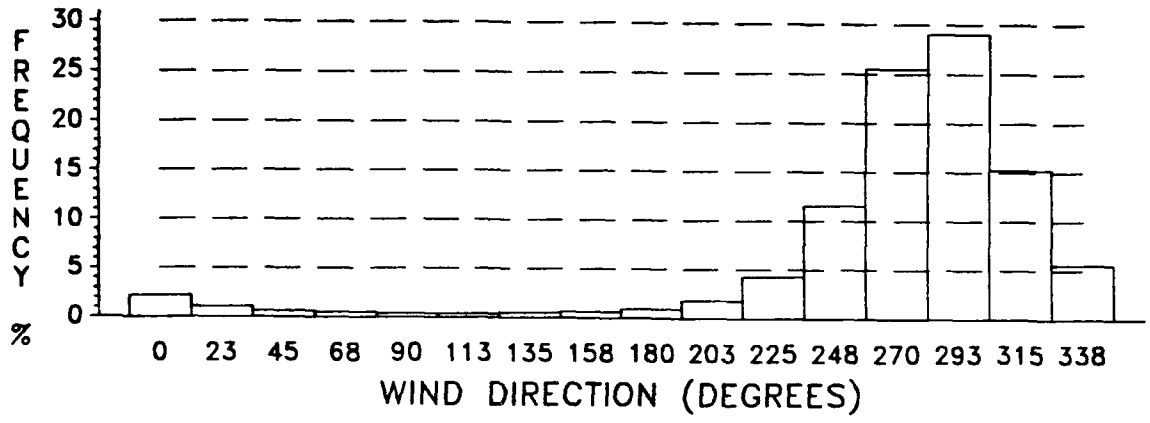

Figure E-7. Wind Direction Frequency, January, 24 KM.

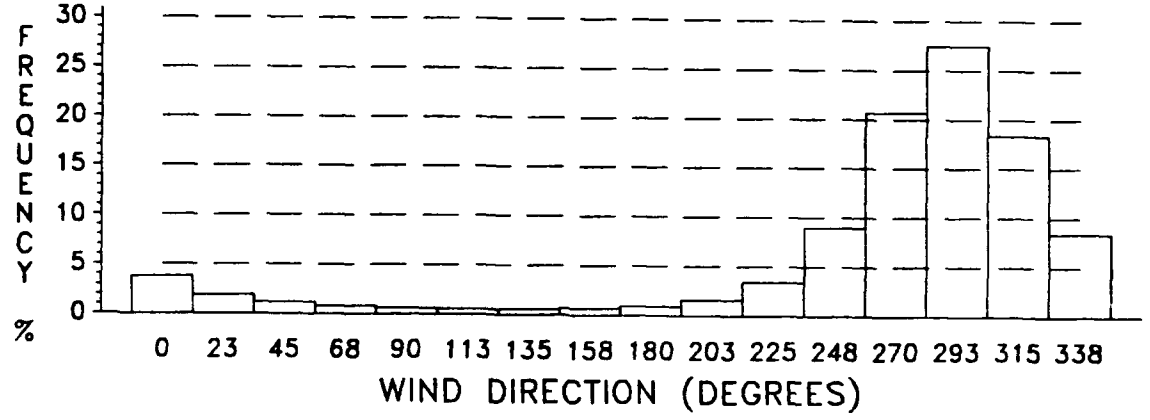

Figure E-8. Wind Direction Frequency, January, 28 KM.

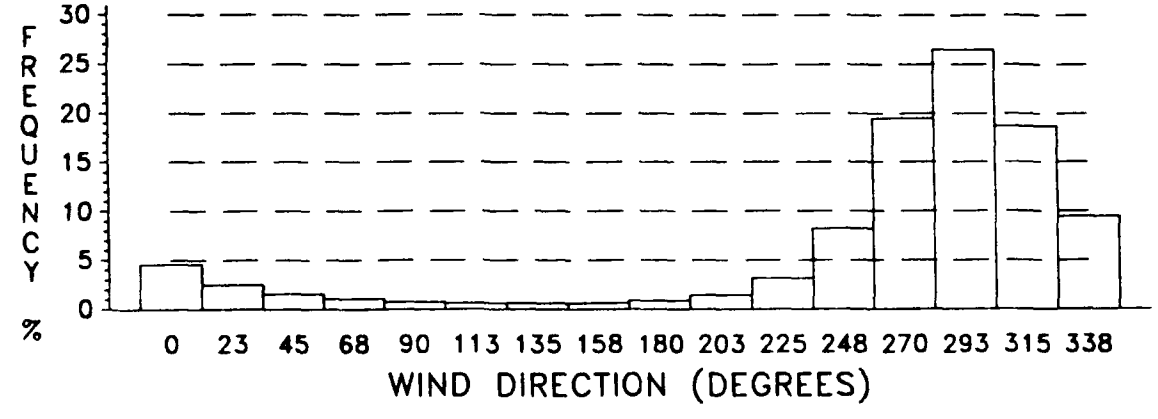

Figure E-9. Wind Direction Frequency, January, 30 KM.

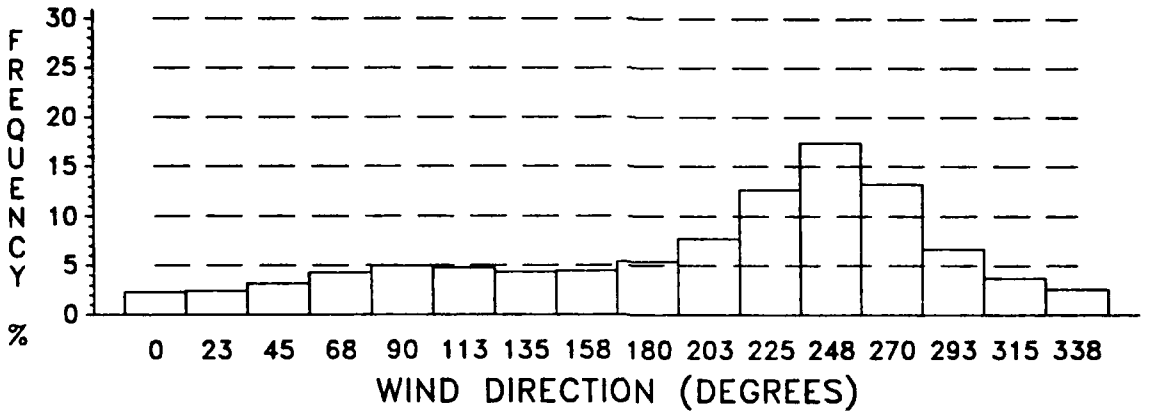

Figure E-10. Wind Direction Frequency, July, 2 KM.

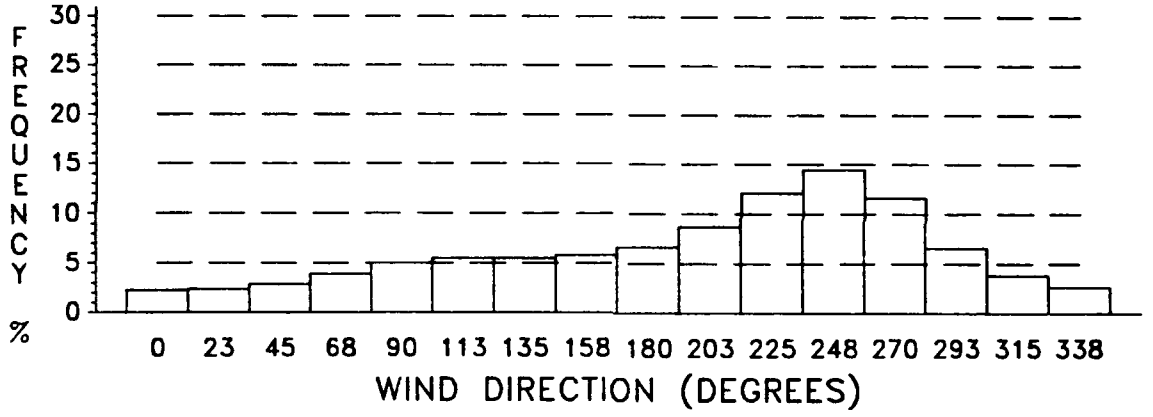

Figure E-11. Wind Direction Frequency, July, 4 KM.

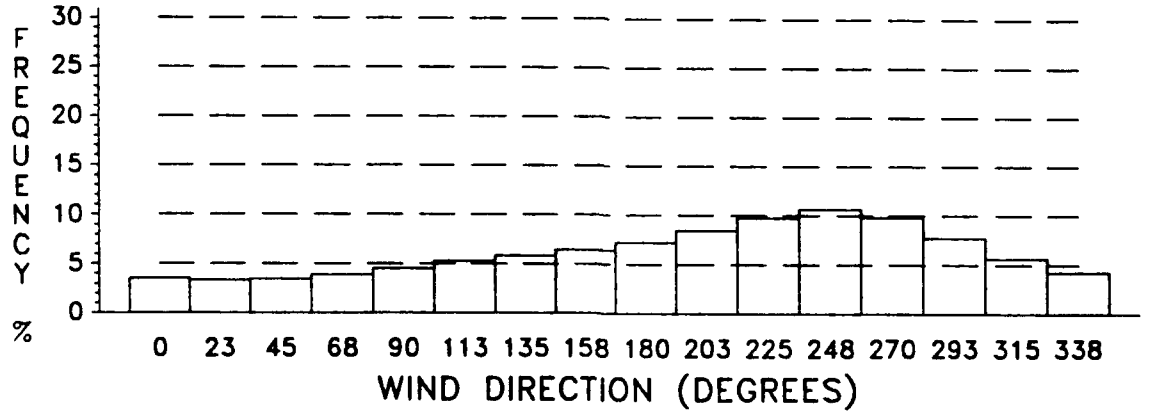

Figure E-12. Wind Direction Frequency, July, 8 KM.

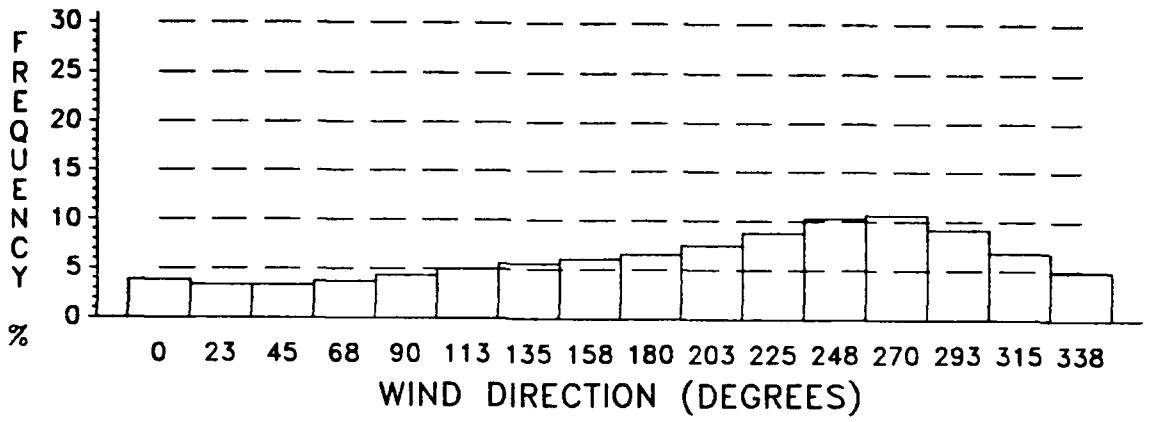

Figure E-13. Wind Direction Frequency, July, 12 KM.

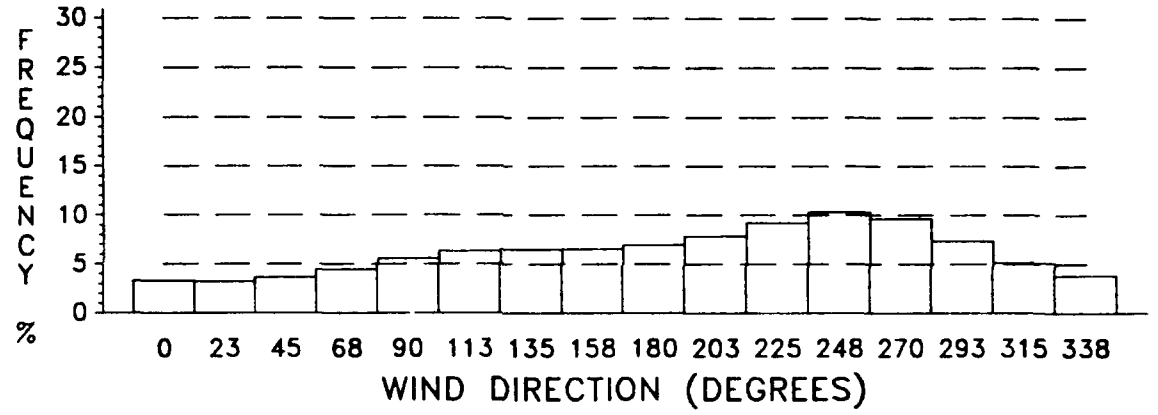

Figure E-14. Wind Direction Frequency, July, 16 KM.

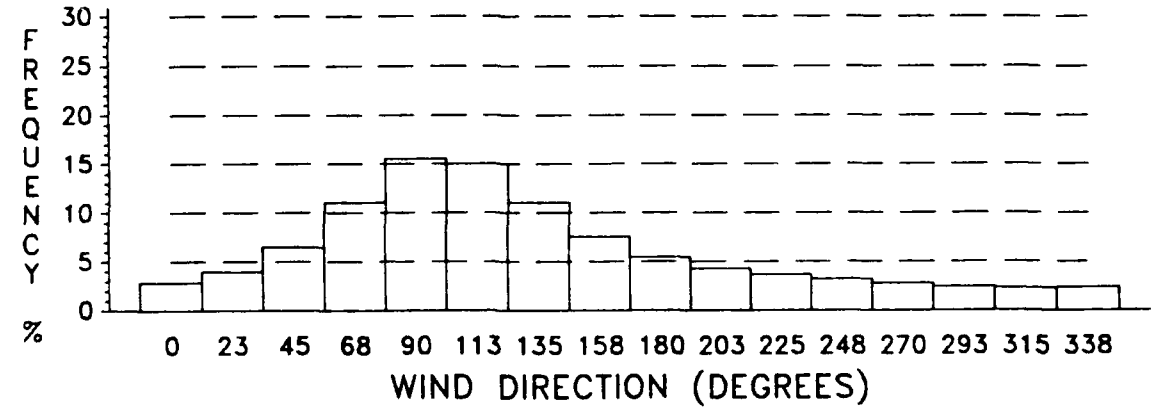

Figure E-15. Wind Direction Frequency, July, 20 KM.

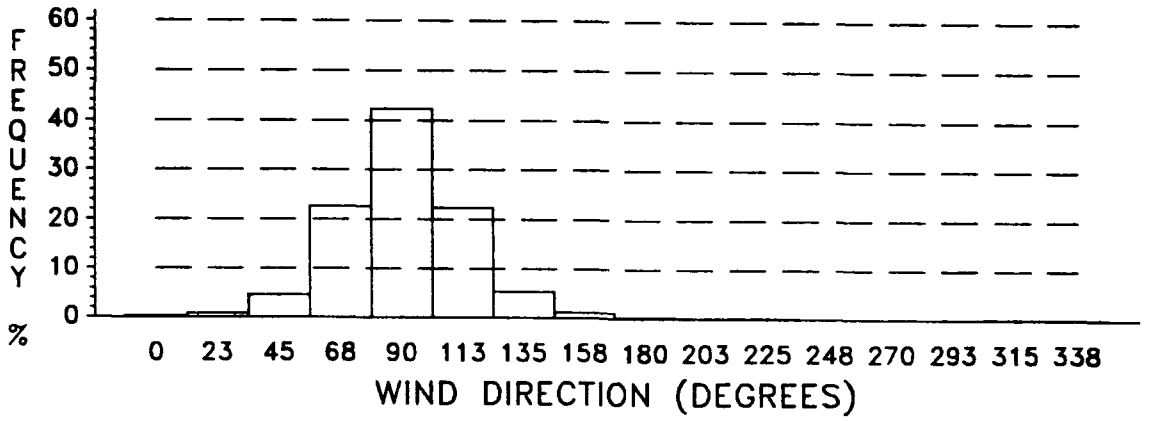

Figure E-16. Wind Direction Frequency, July, 24 KM.

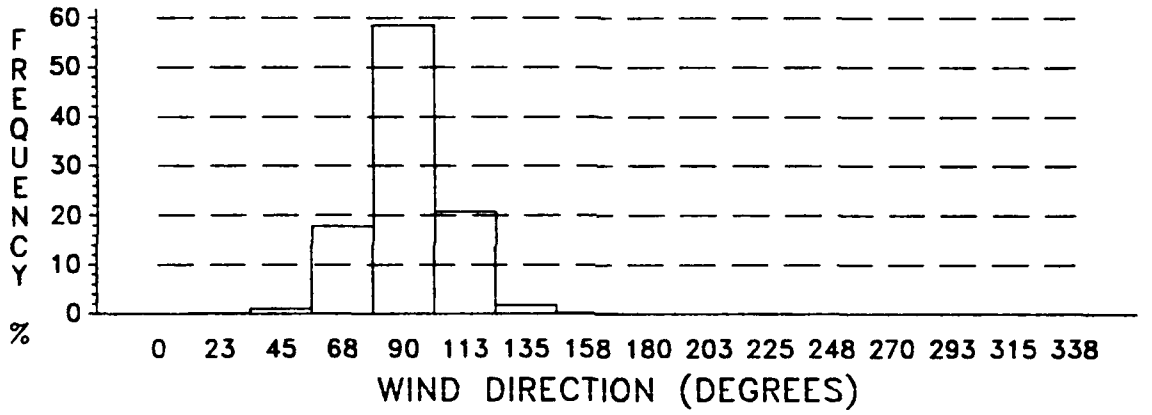

Figure E-17. Wind Direction Frequency, July, 28 KM.

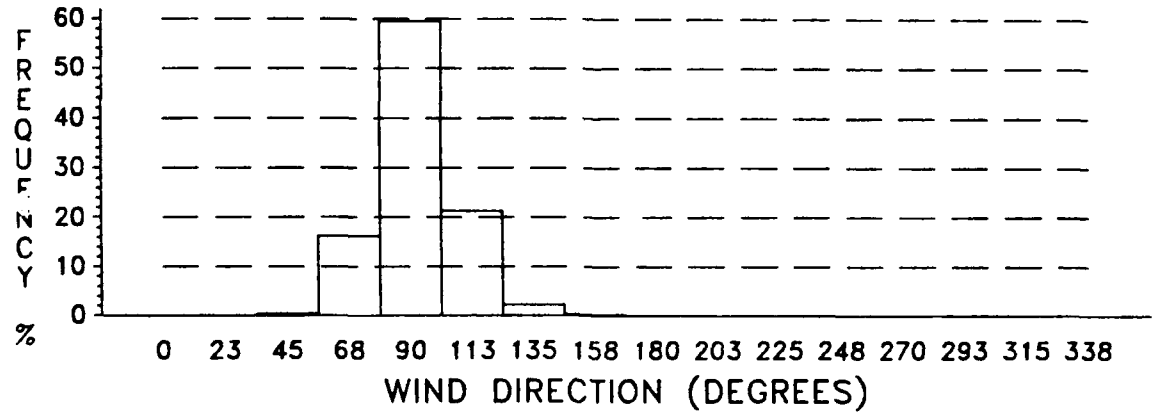

Figure E-18. Wind Direction Frequency, July, 30 KM

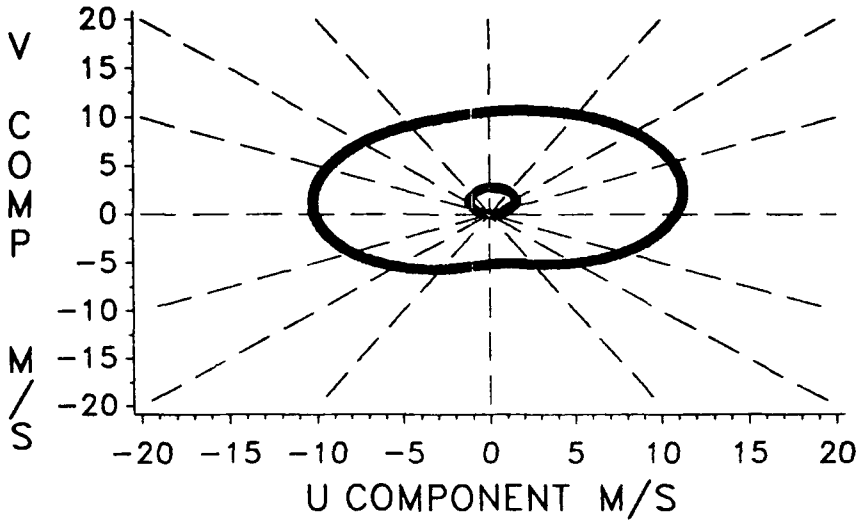

Figure E-19. Wind Interpercentile Range and Mean, January, 2 KM.

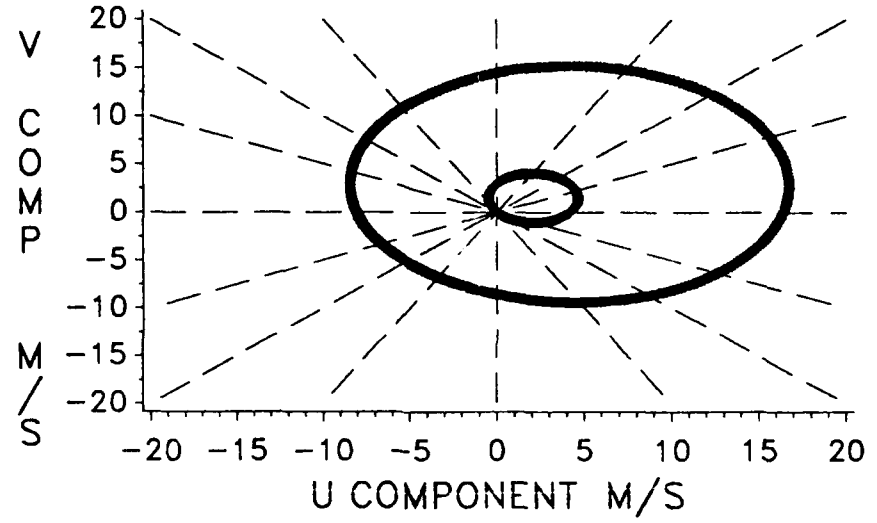

Figure E-20. Wind Interpercentile Range and Mean, January, 4 KM.

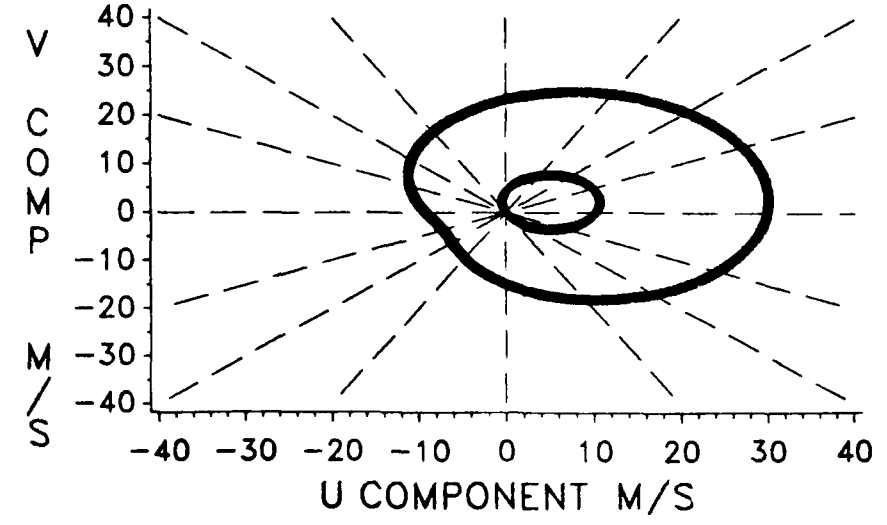

Figure E-21. Wind Interpercentile Range and Mean, January, 8 KM.

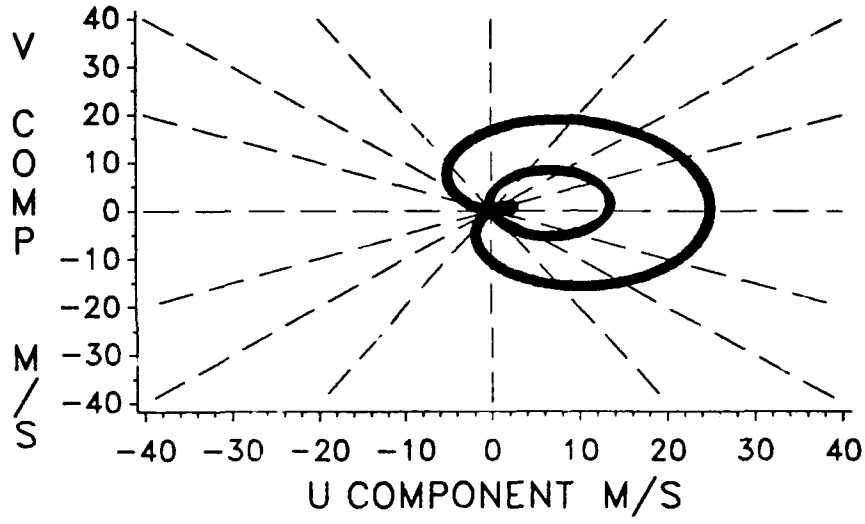

Figure E-22. Wind Interpercentile Range and Mean, January, 12 KM.

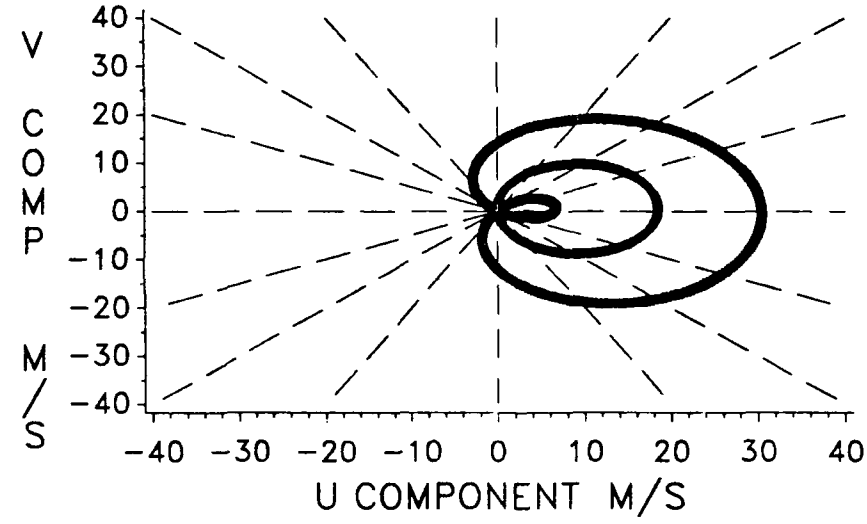

Figure E-23. Wind Interpercentile Range and Mean, January, 16 KM.

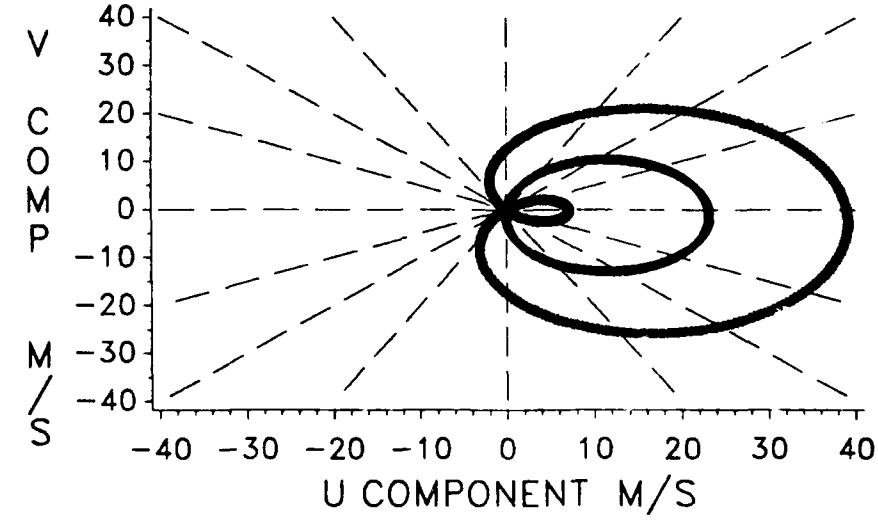

Figure E-24. Wind Interpercentile Range and Mean, January, 20 KM.

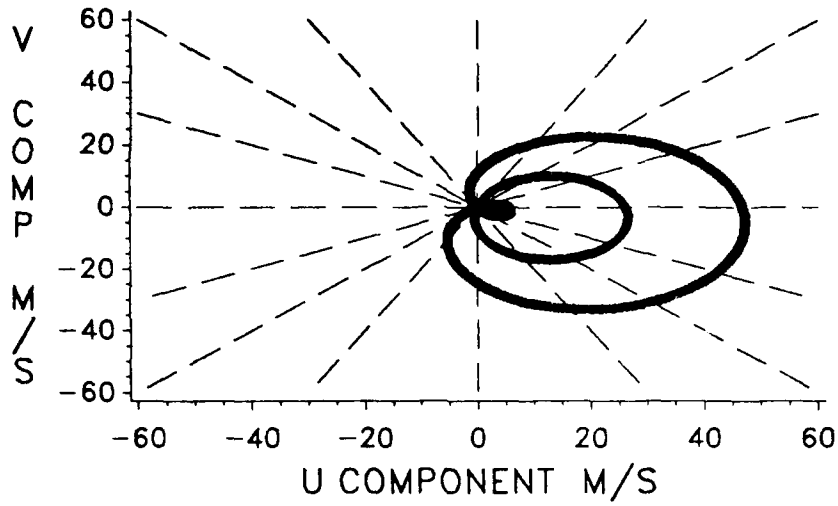

Figure E-25. Wind Interpercentile Range and Mean, January, 24 KM.

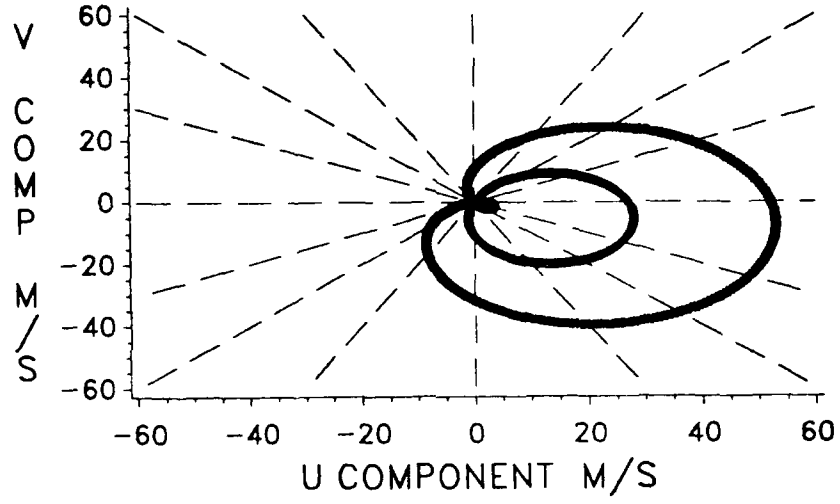

Figure E-26. Wind Interpercentile Range and Mean, January, 28 KM.

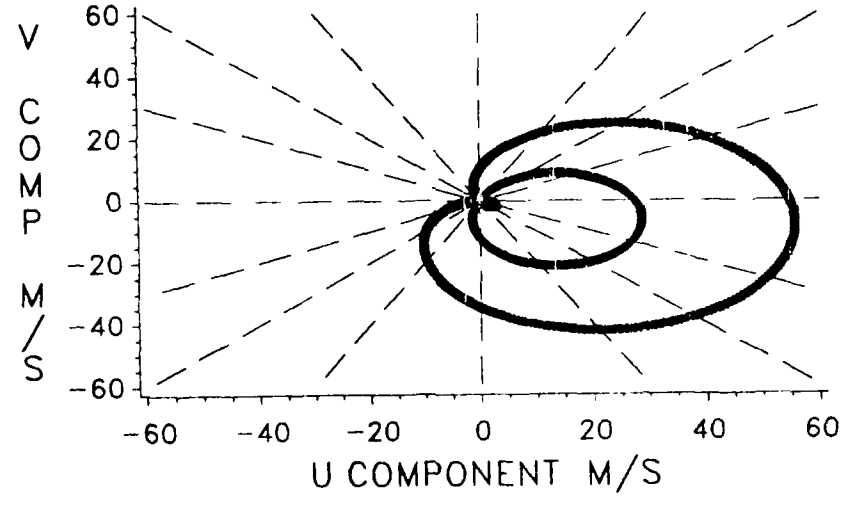

Figure E-27. Wind Interpercentile Range and Mean, January, 30 KM.

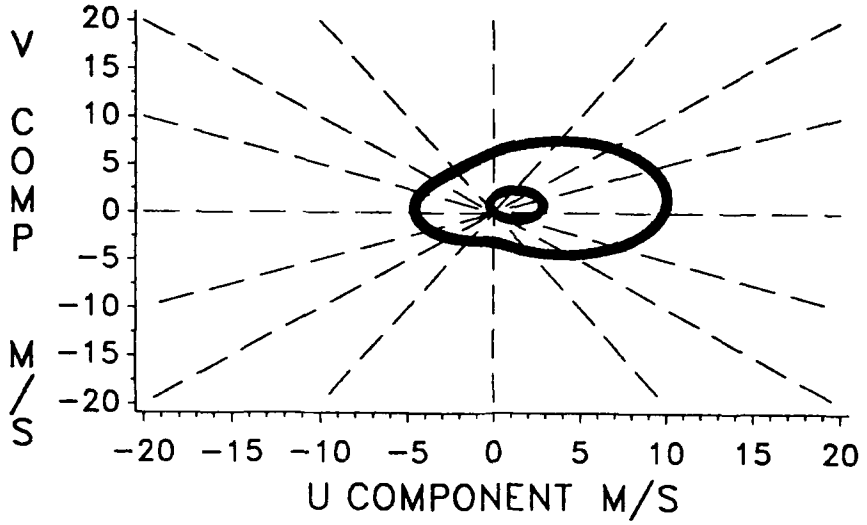

Figure E-28. Wind Interpercentile Range and Mean, July, 2 KM.

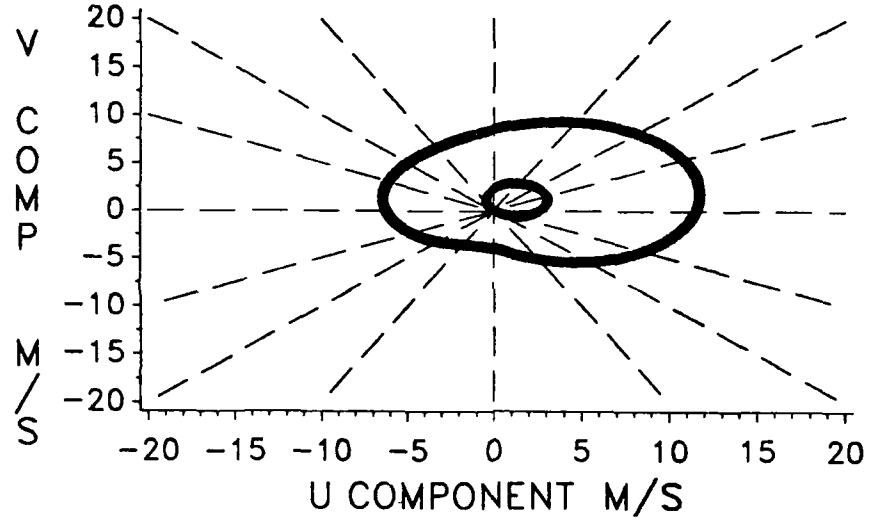

Figure E-29. Wind Interpercentile Range and Mean, July, 4 KM.

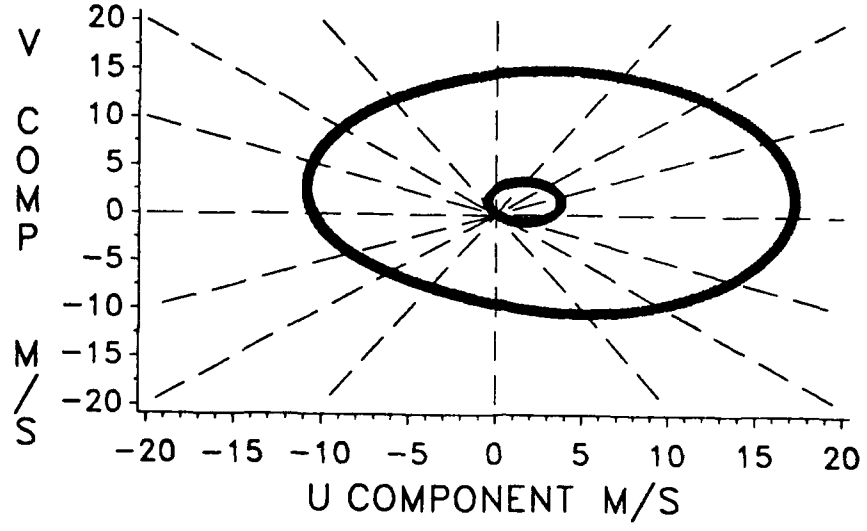

Figure E-30. Wind Interpercentile Range and Mean, July, 8 KM.

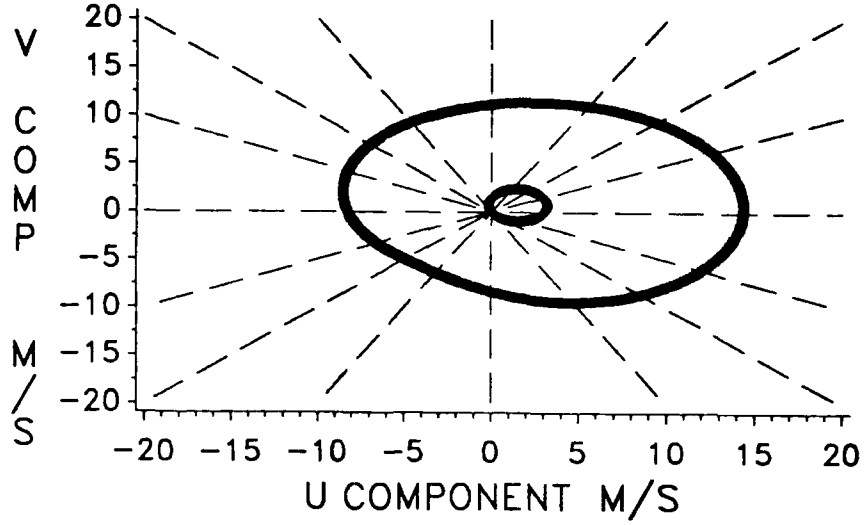

Figure E-31. Wind Interpercentile Range and Mean, July, 12 KM.

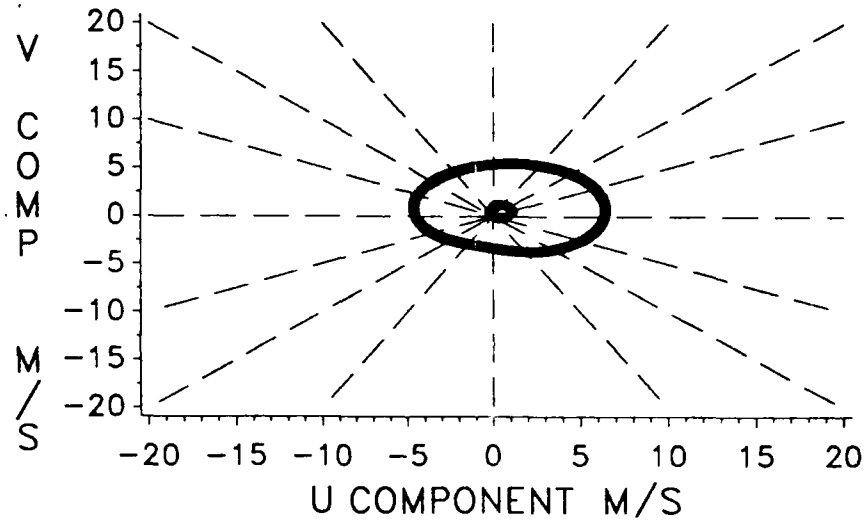

Figure E-32. Wind Interpercentile Range and Mean, July, 16 KM.

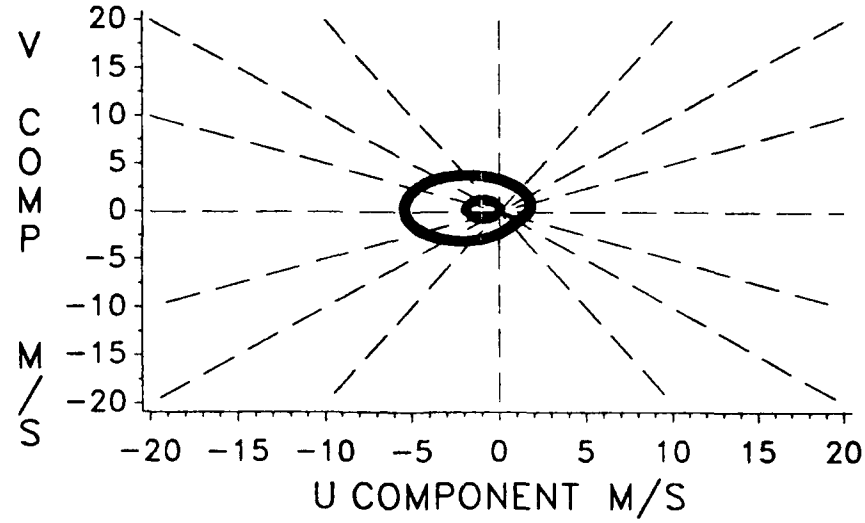

Figure E-33. Wind Interpercentile Range and Mean, July, 20 KM.

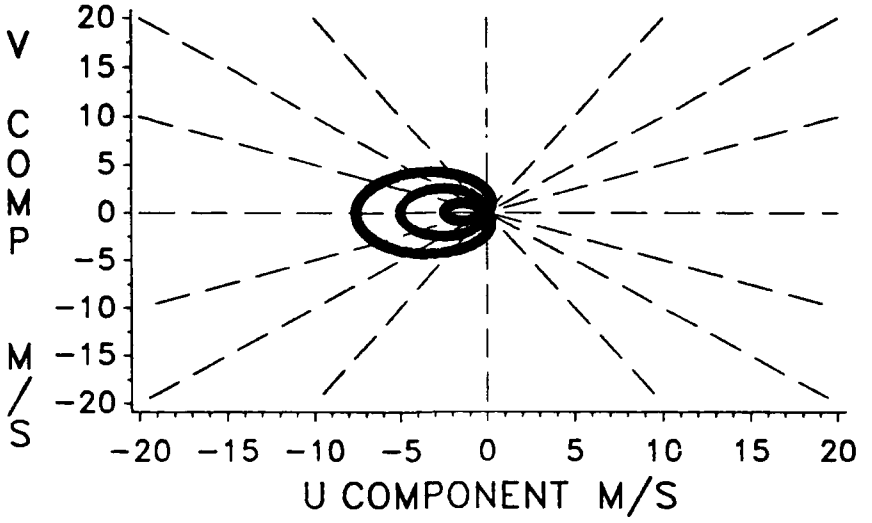

Figure E-34. Wind Interpercentile Range and Mean, July, 24 KM.

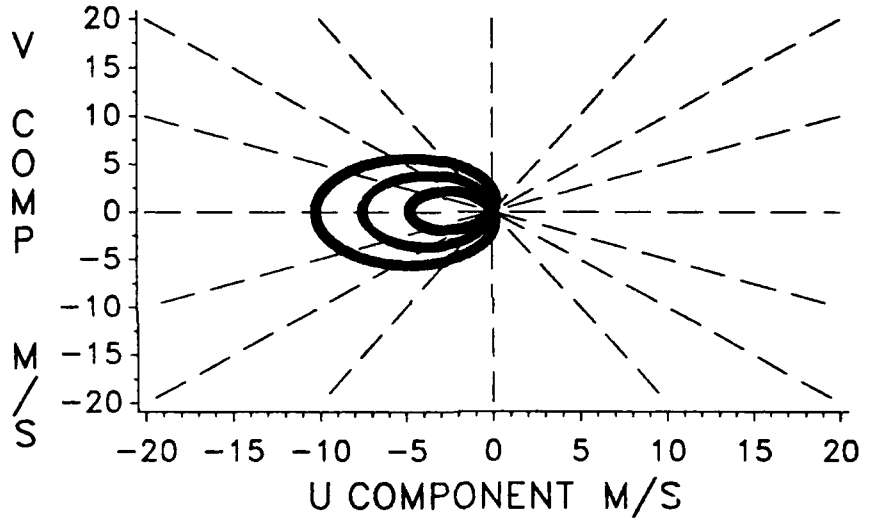

Figure E-35. Wind Interpercentile Range and Mean, July, 28 KM.

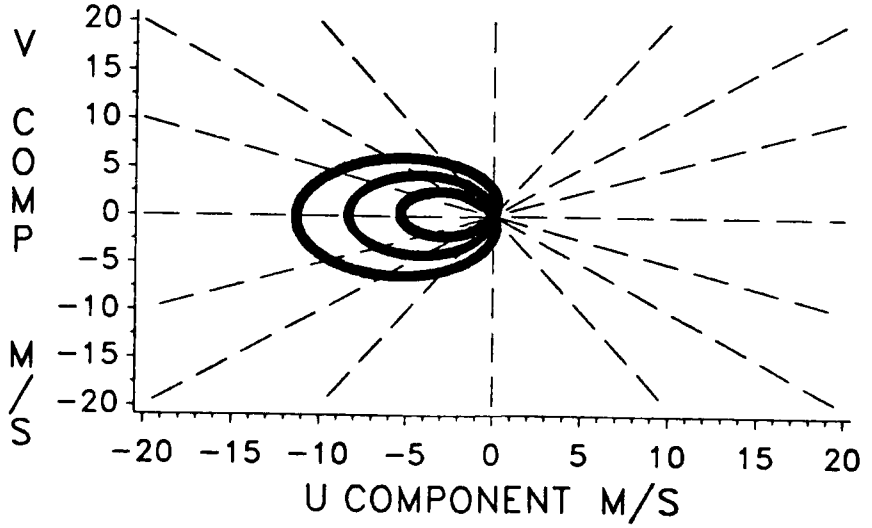

Figure E-36. Wind Interpercentile Range and Mean, July, 30 KM.

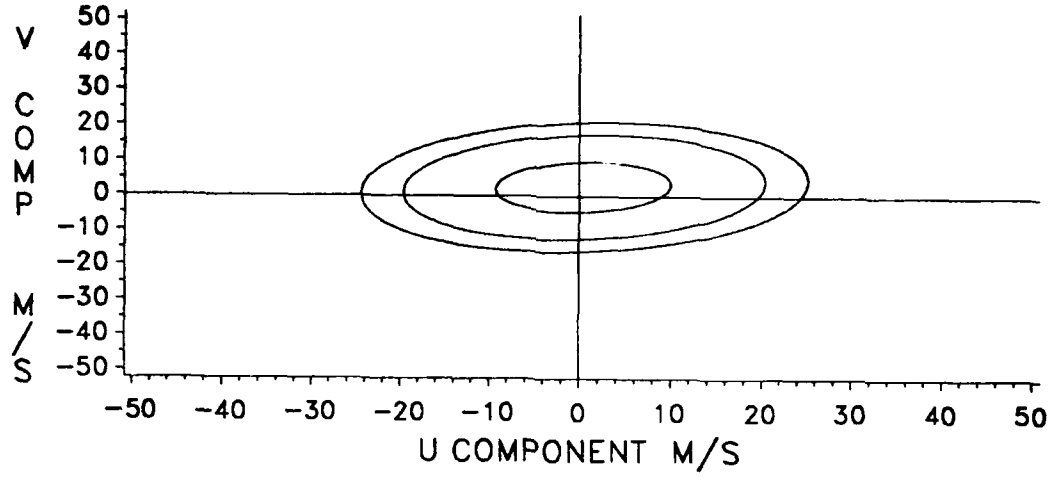

Figure E-37. Wind Probability Ellipses, January, 2 KM.

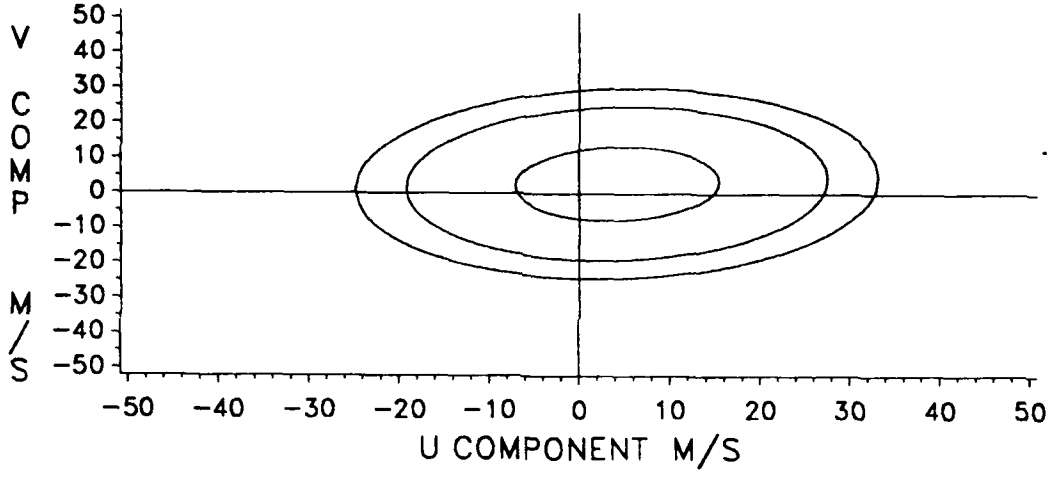

Figure E-38. Wind Probability Ellipses, January, 4 KM.

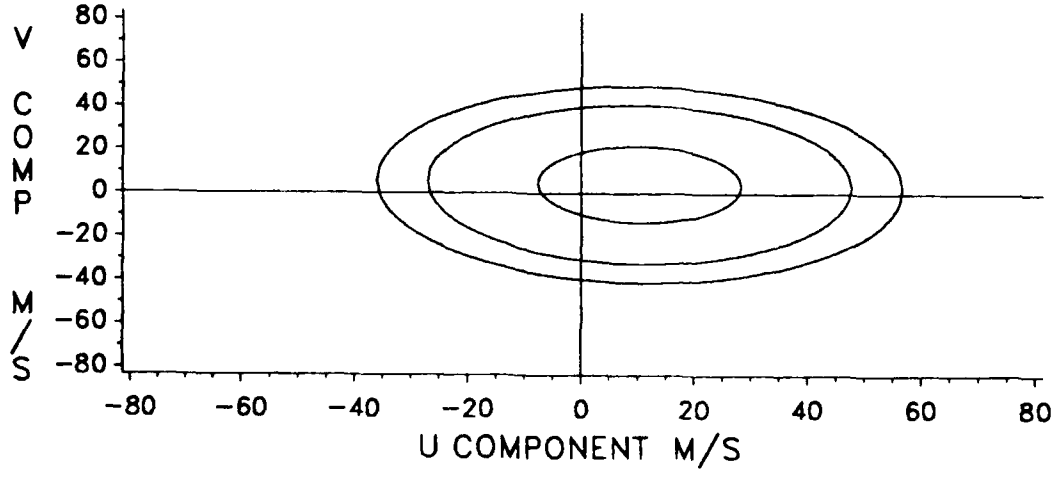

Figure E-39. Wind Probability Ellipses, January, 8 KM.

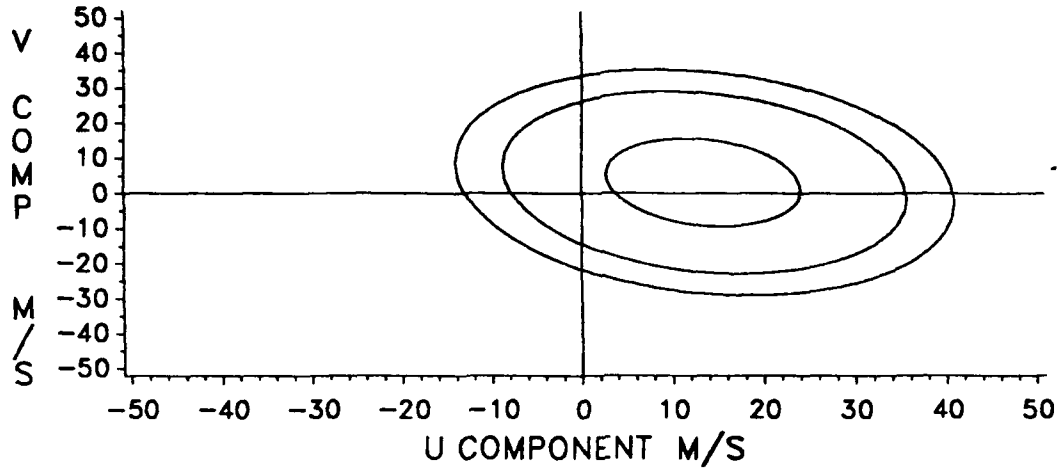

Figure E-40. Wind Probability Ellipses, January, 12 KM.

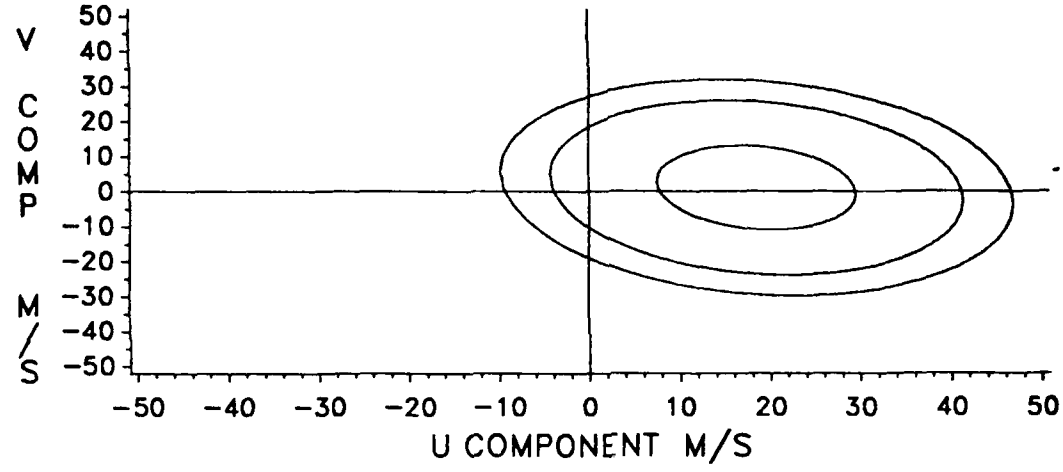

Figure E-41. Wind Probability Ellipses, January, 16 KM.

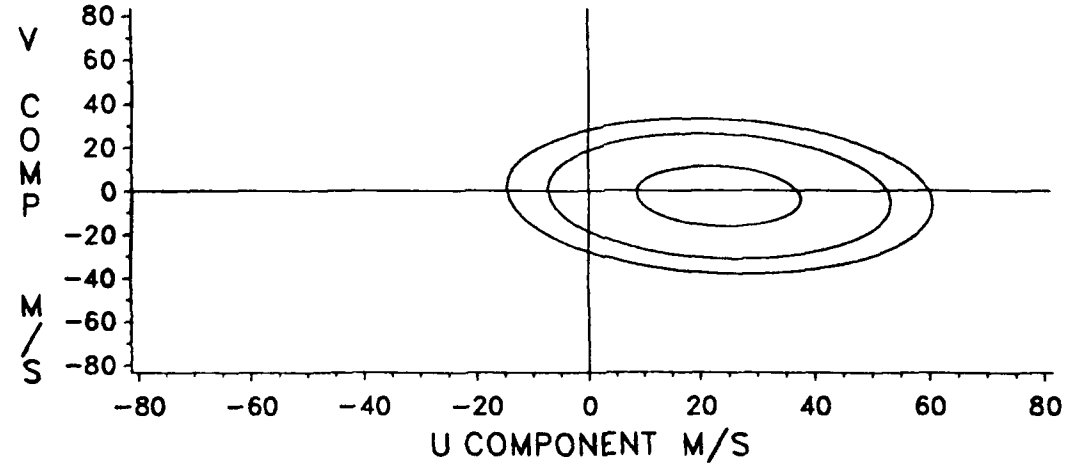

Figure E-42. Wind Probability Ellipses, January, 20 KM.

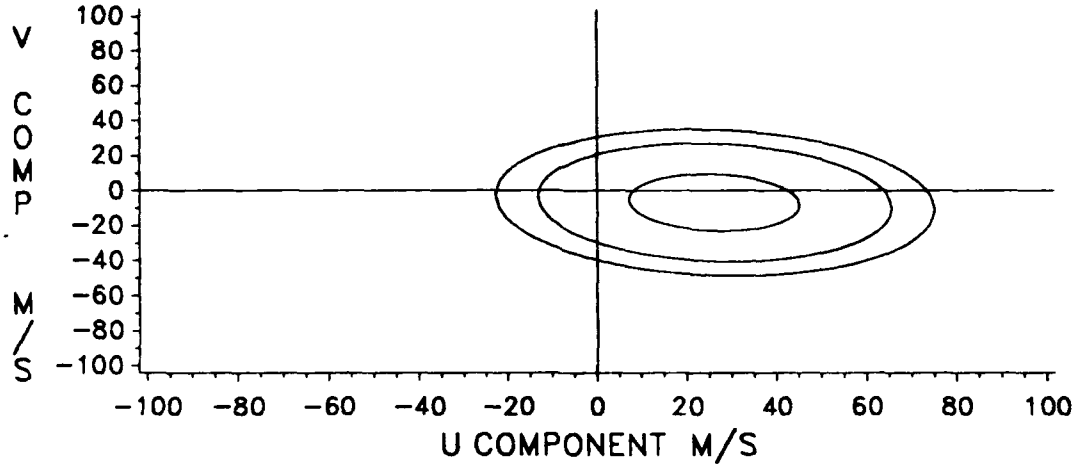

Figure E-43. Wind Probability Ellipses, January, 24 KM.

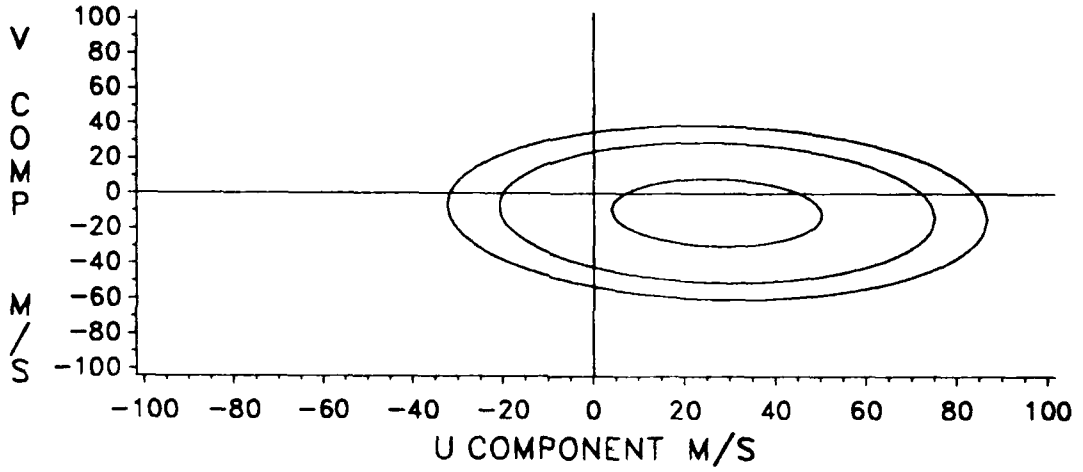

Figure E-44. Wind Probability Ellipses, January, 28 KM.

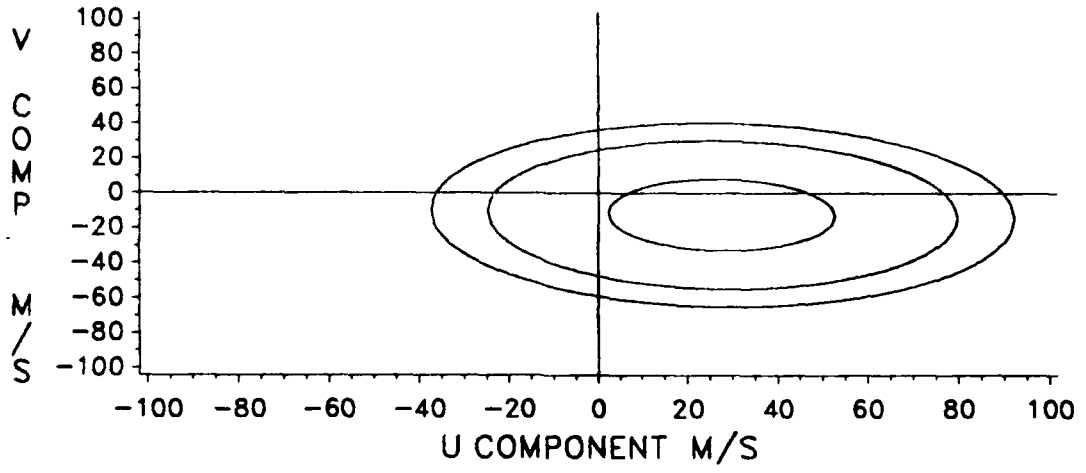

Figure E-45. Wind Probability Ellipses, January, 30 KM.

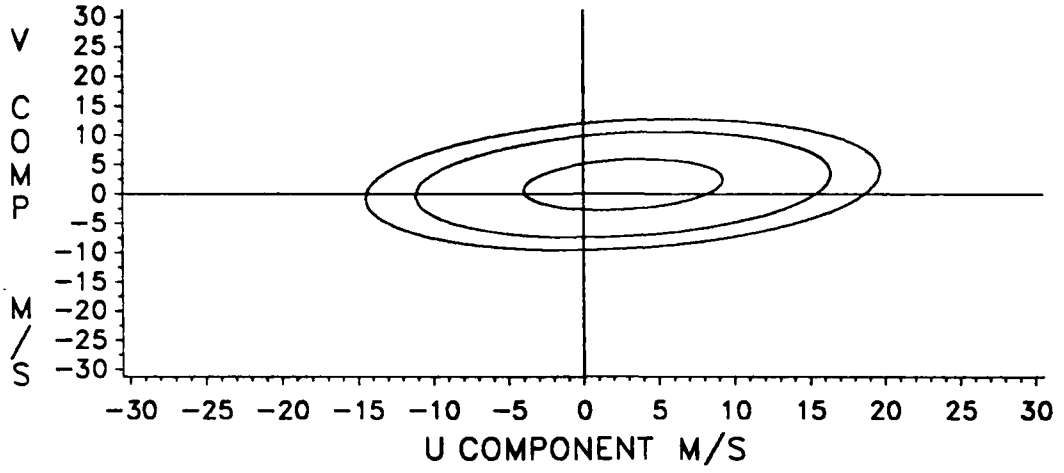

Figure E-46. Wind Probability Ellipses, July, 2 KM.

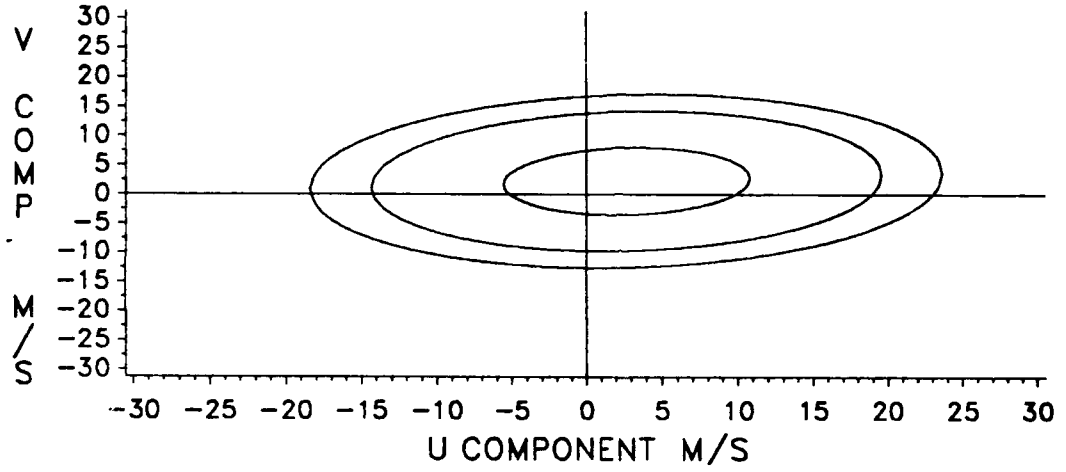

Figure E-47. Wind Probability Ellipses, July, 4 KM.

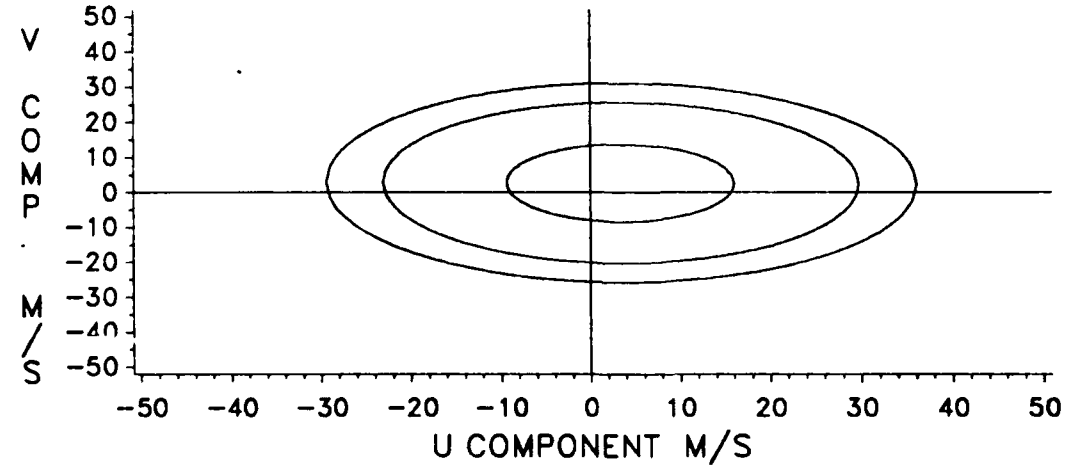

Figure E-48. Wind Probability Ellipses, July, 8 KM.

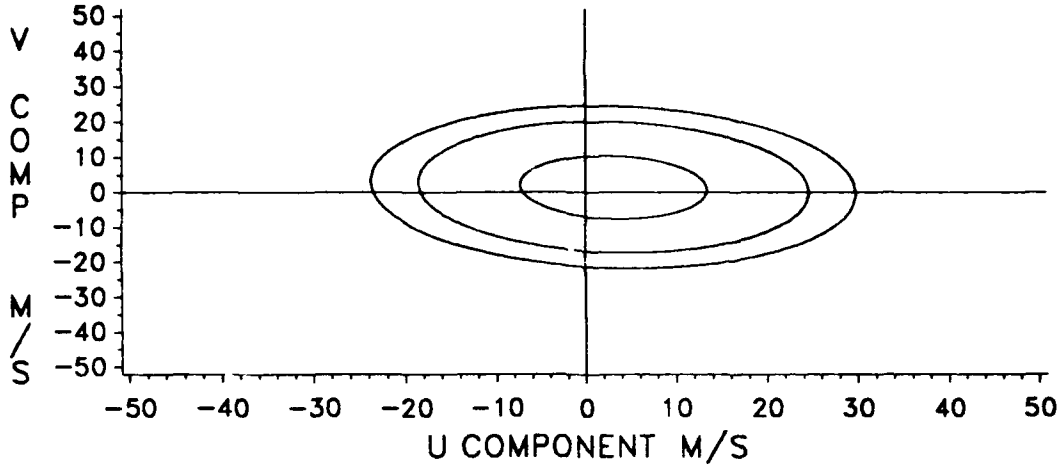

Figure E-49. Wind Probability Ellipses, July, 12 KM.

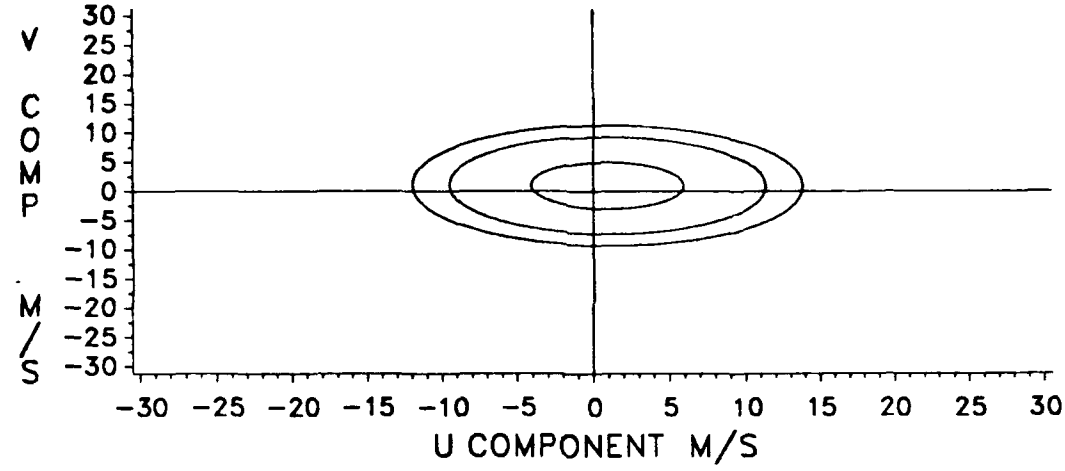

Figure E-50. Wind Probability Ellipses, July, 16 KM.

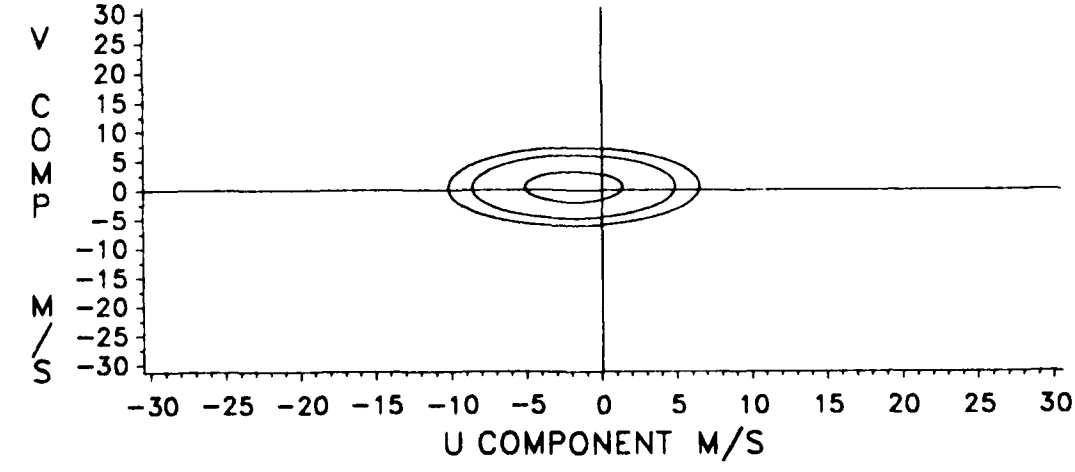

Figure E-51. Wind Probability Ellipses, July 20 KM.

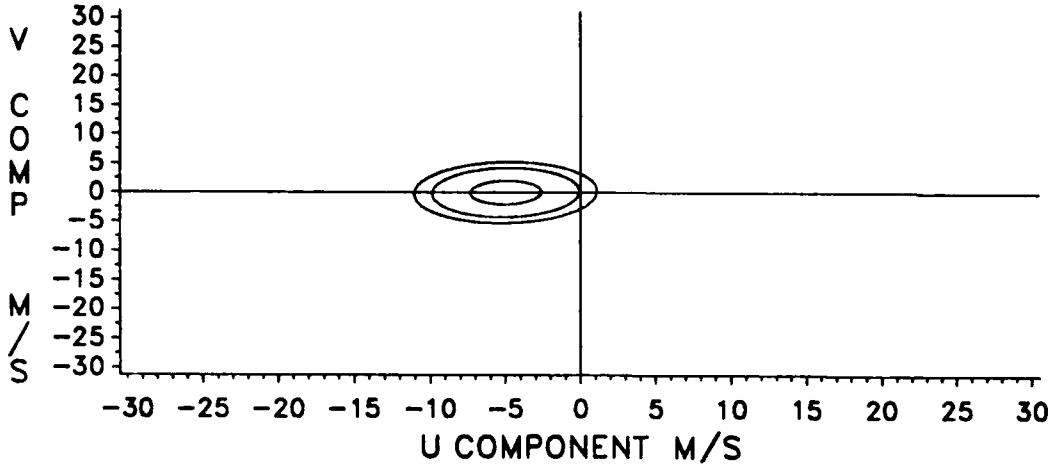

Figure E-52. Wind Probability Ellipses, July, 24 KM.

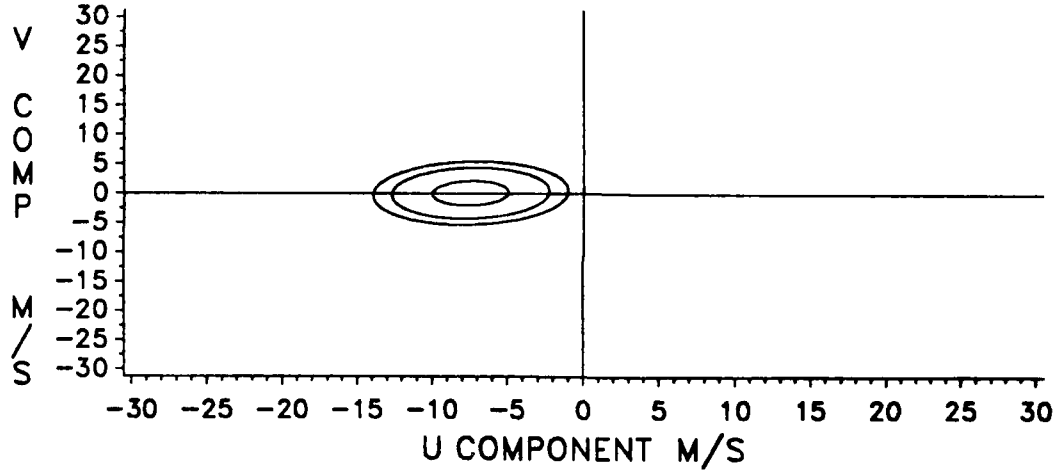

Figure E-53. Wind Probability Ellipses, July, 28 KM.

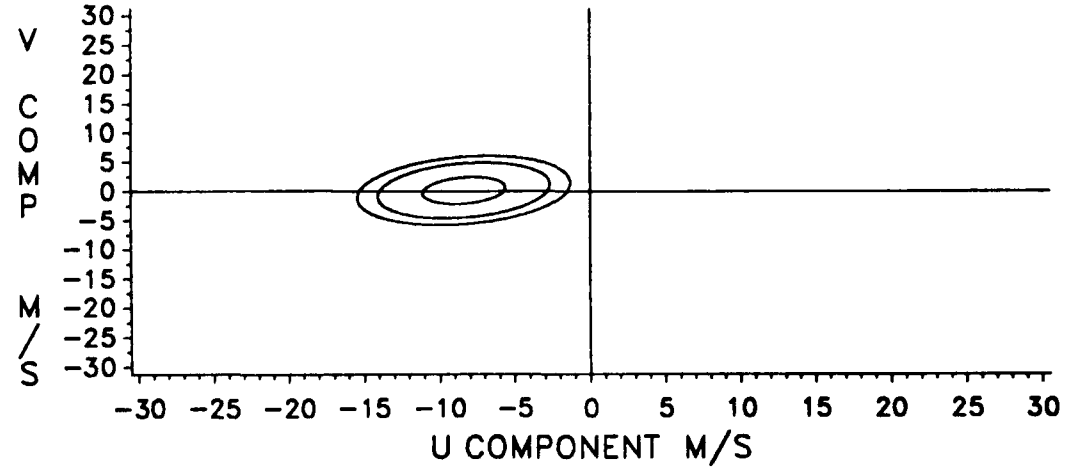

Figure E-54. Wind Probability Ellipses, July, 30 KM.

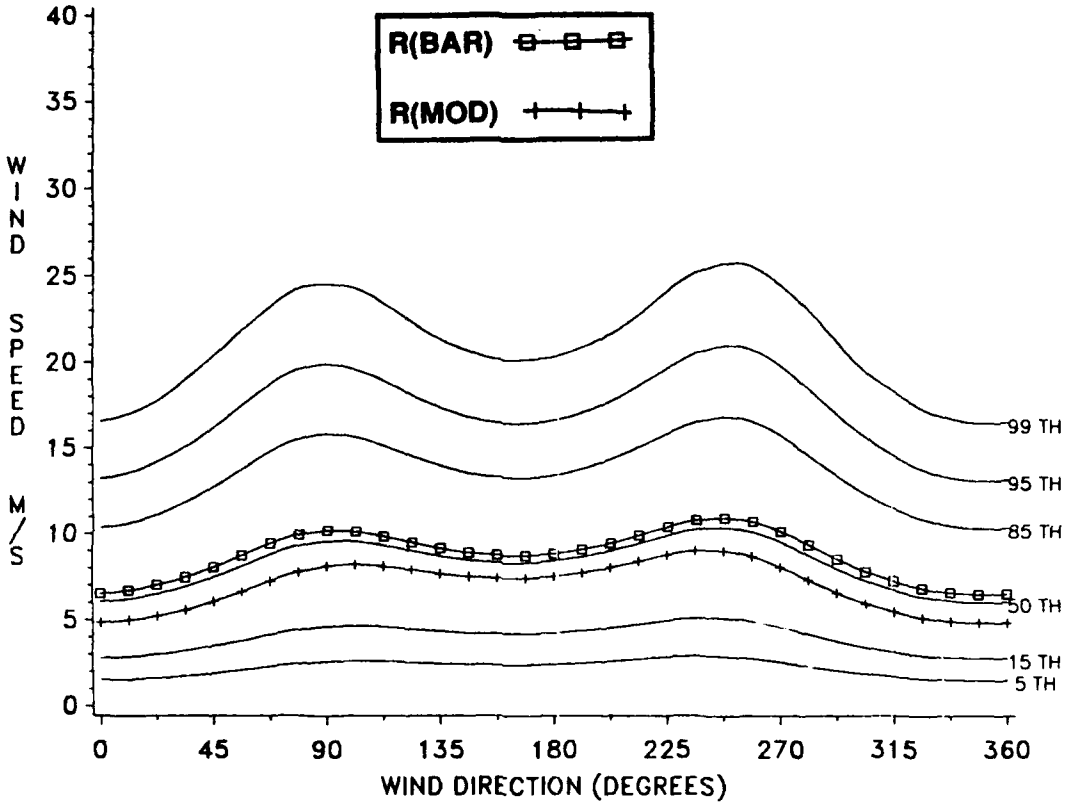

Figure E-55. Conditional Wind Speed Given Direction, January, 2 KM.

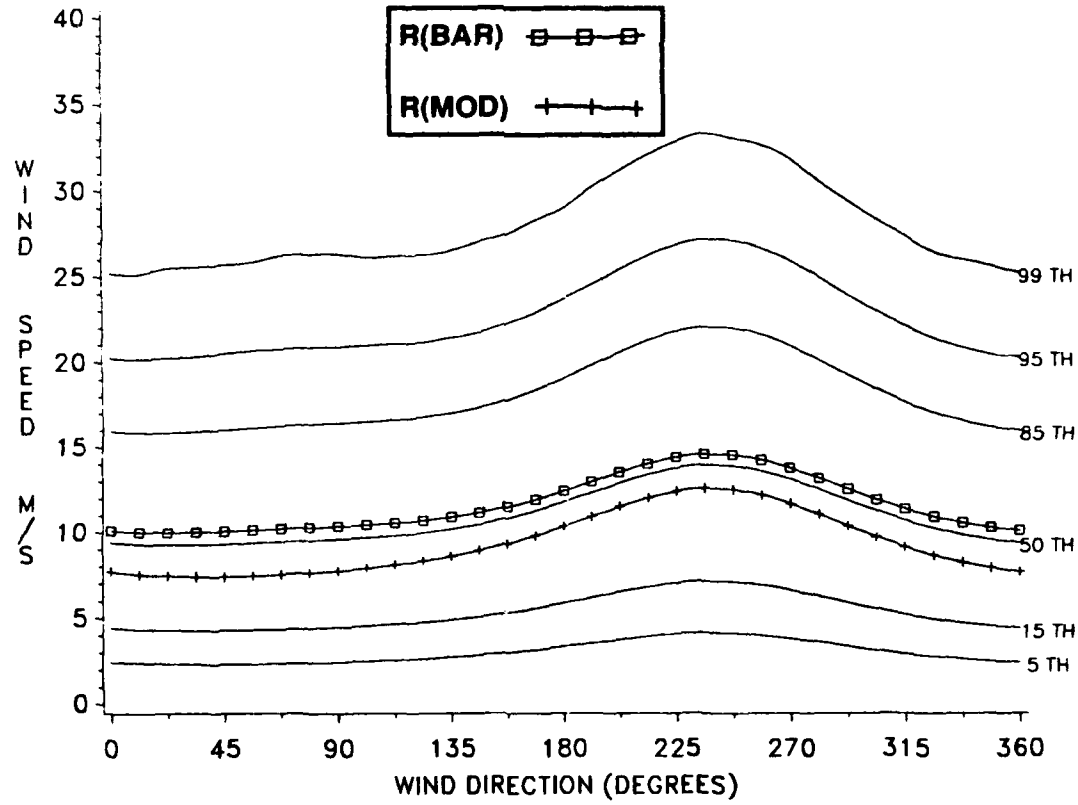

Figure E-56. Conditional Wind Speed Given Direction, January, 4 KM.

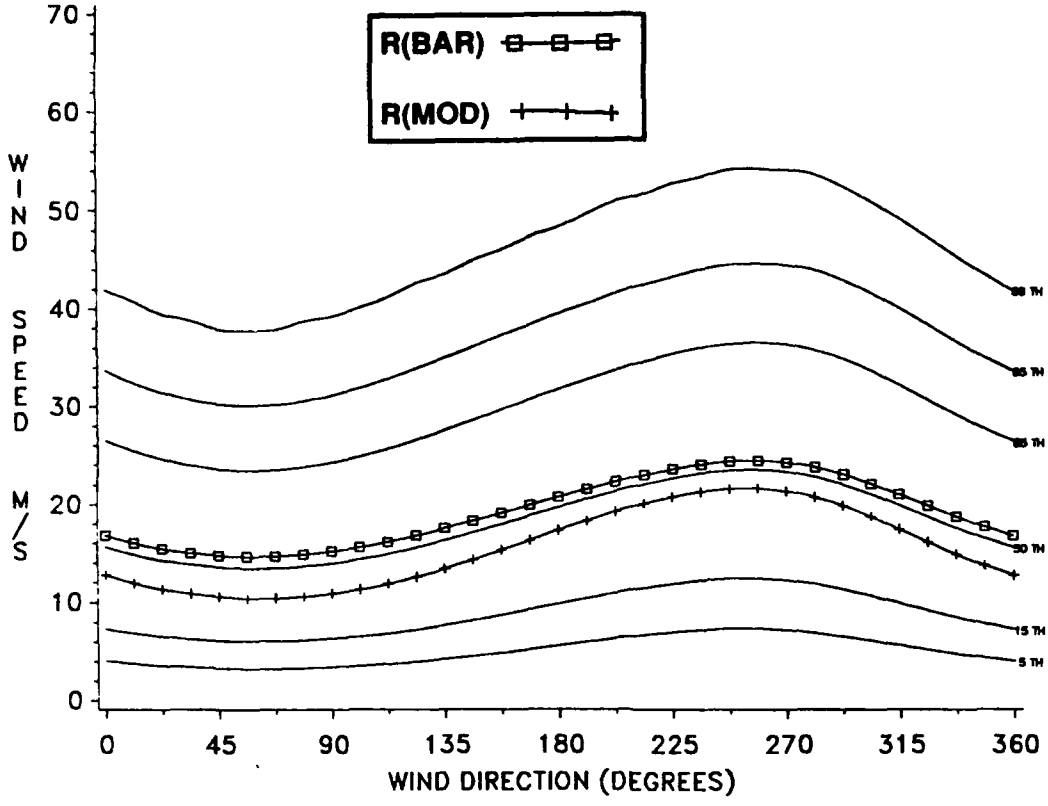

Figure E-57. Conditional Wind Speed Given Direction, January, 8 KM.

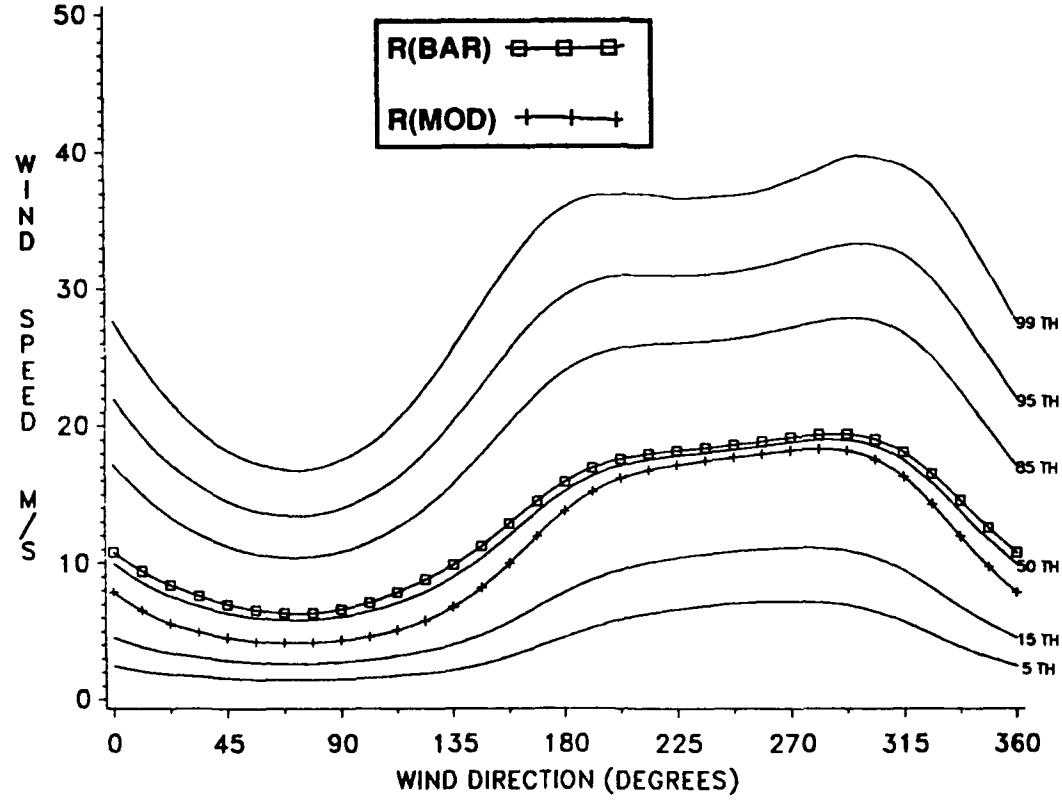

Figure E-58. Conditional Wind Speed Given Direction, January, 12 KM.

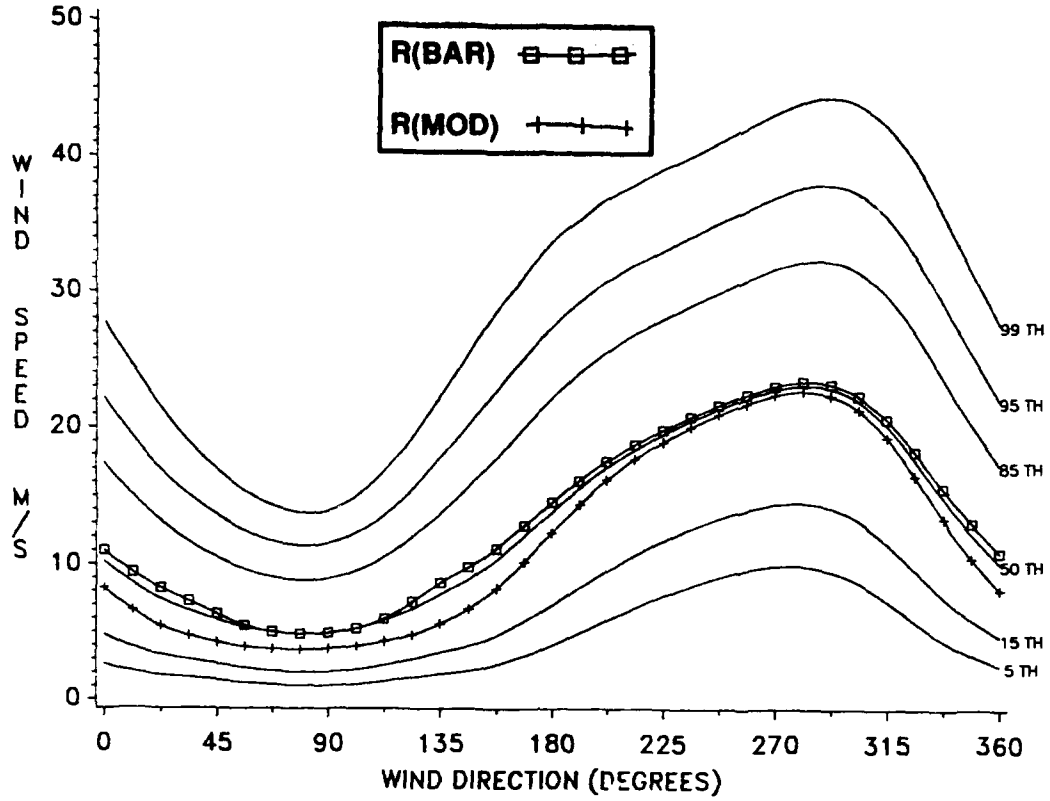

Figure E-59. Conditional Wind Speed Given Direction, January, 16 KM.

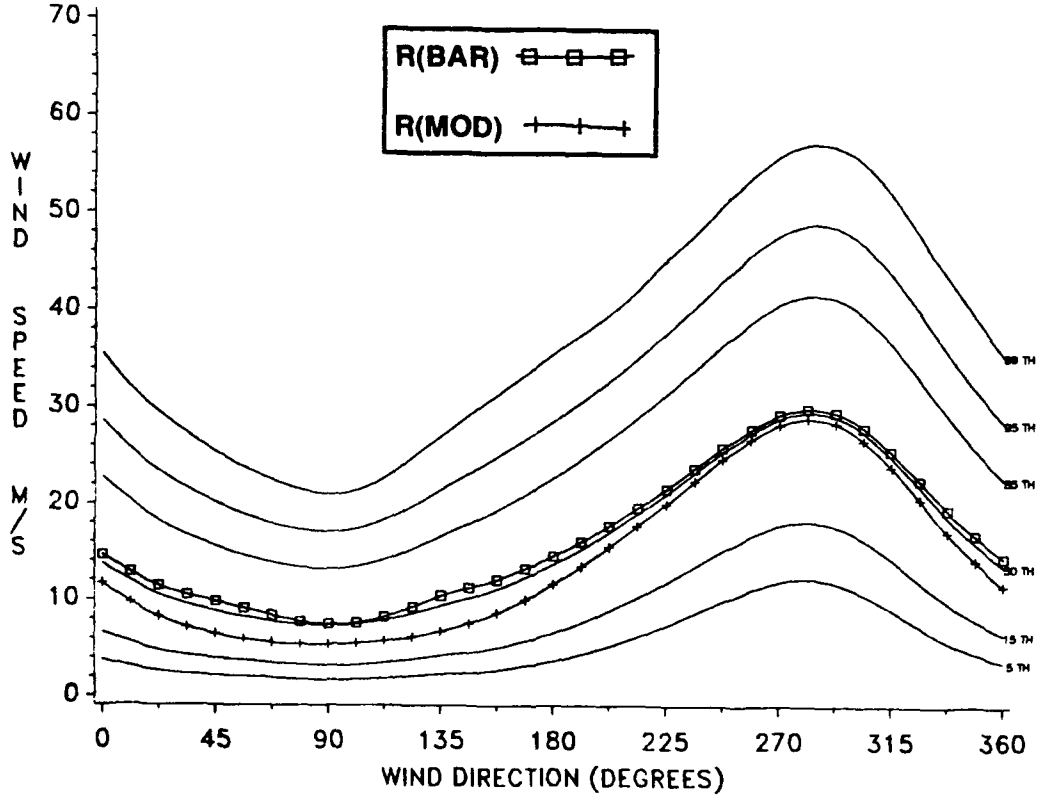

Figure E-60. Conditional Wind Speed Given Direction, January, 20 KM.

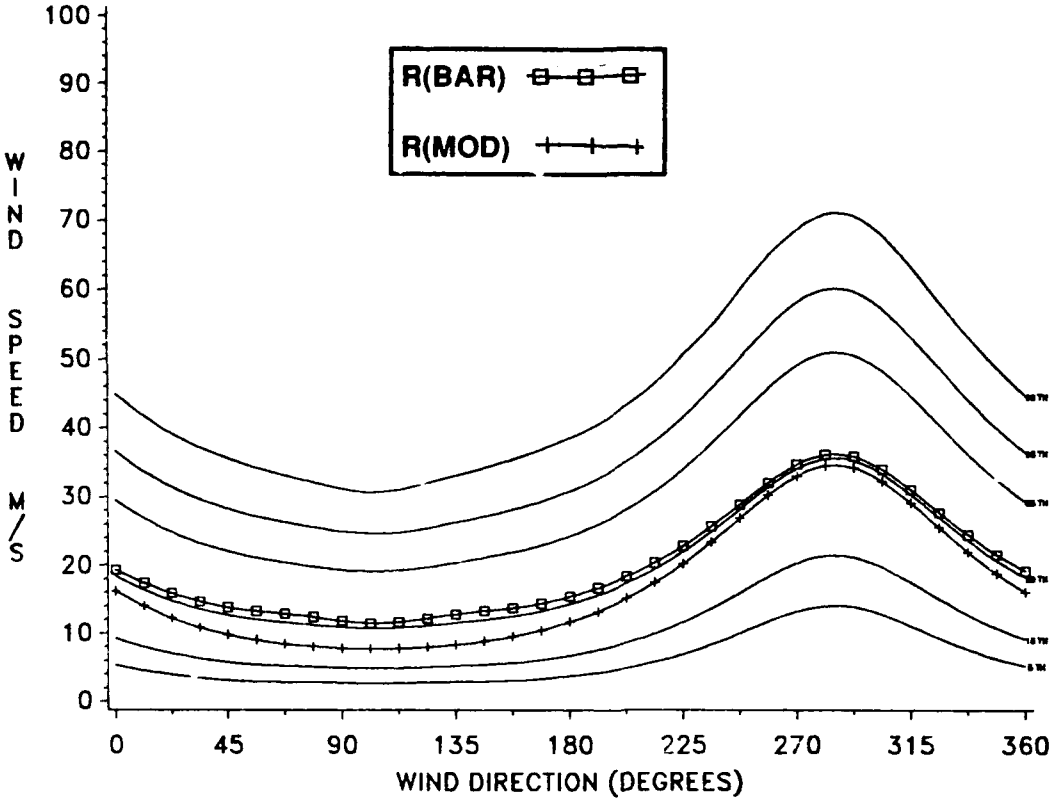

Figure E-61. Conditional Wind Speed Given Direction, January, 24 KM.

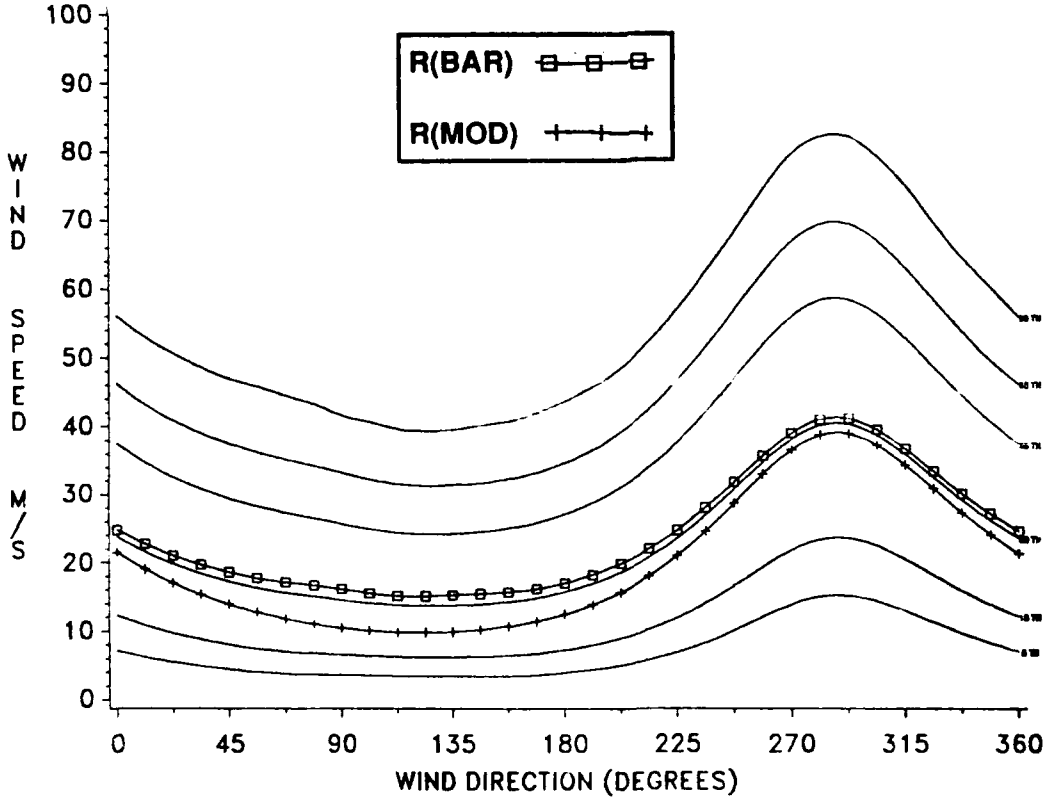

Figure E-62. Conditional Wind Speed Given Direction, January, 28 KM.

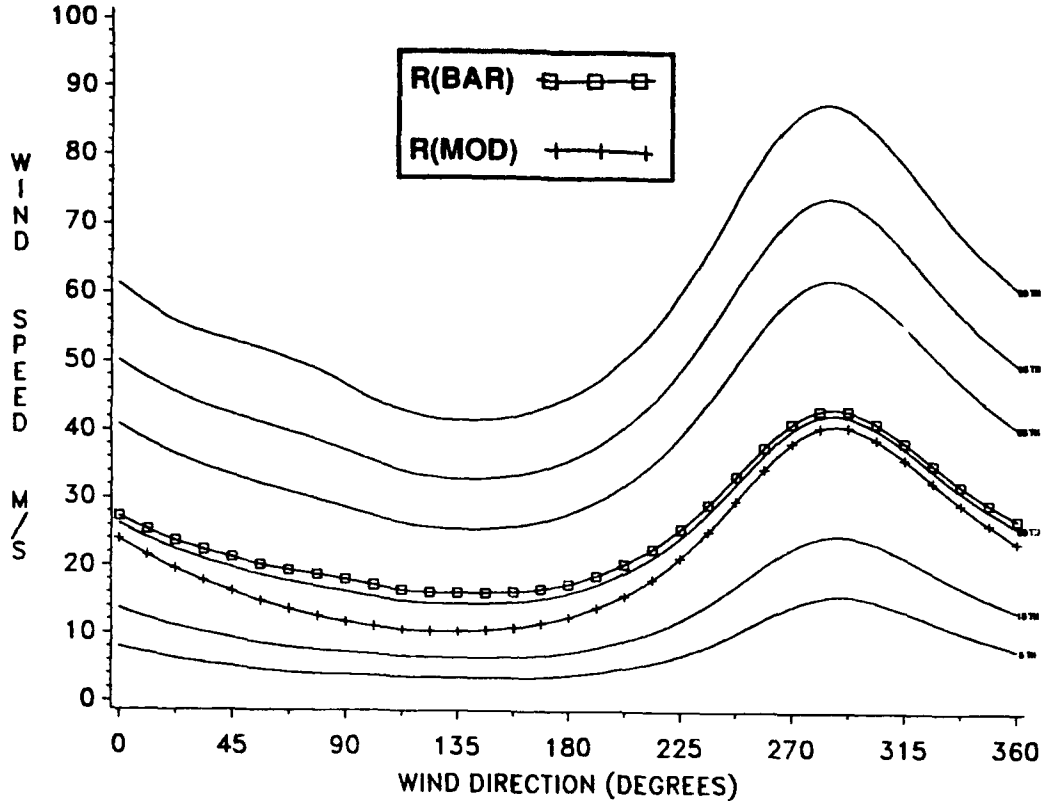

Figure E-63. Conditional Wind Speed Given Direction, January, 30 KM.

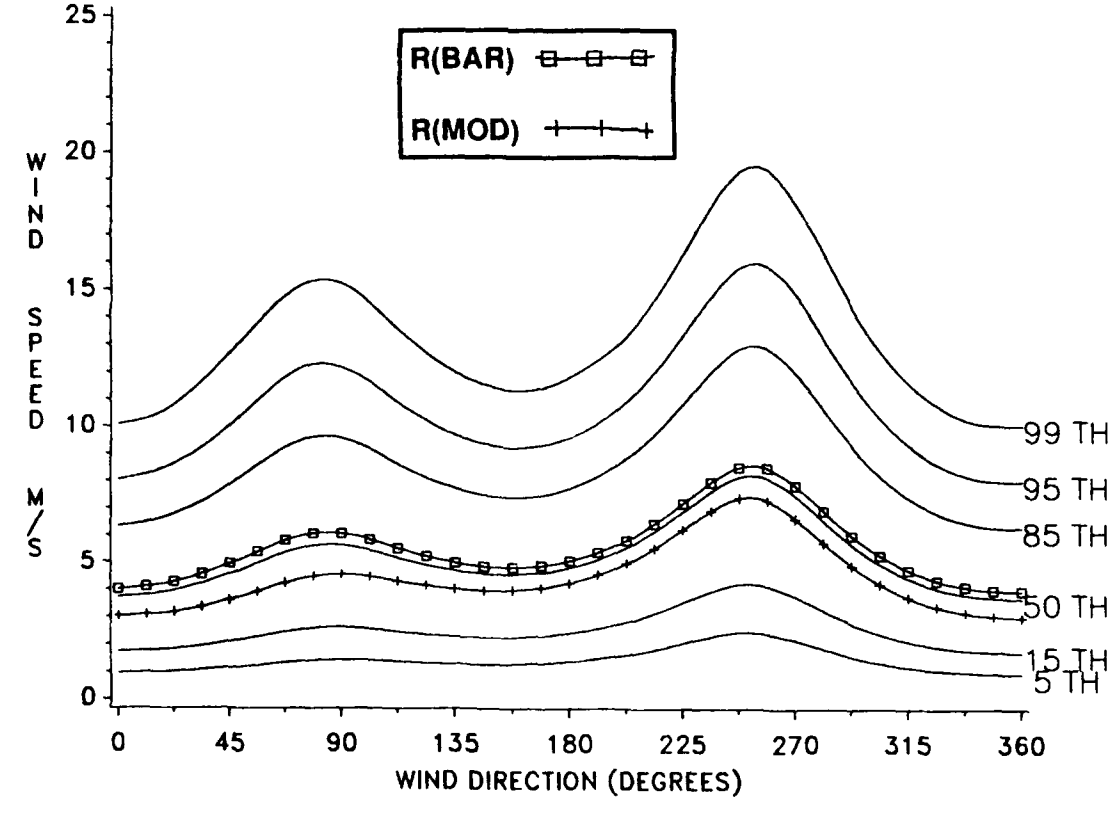

Figure E-64. Conditional Wind Speed Given Direction, July, 2 KM.

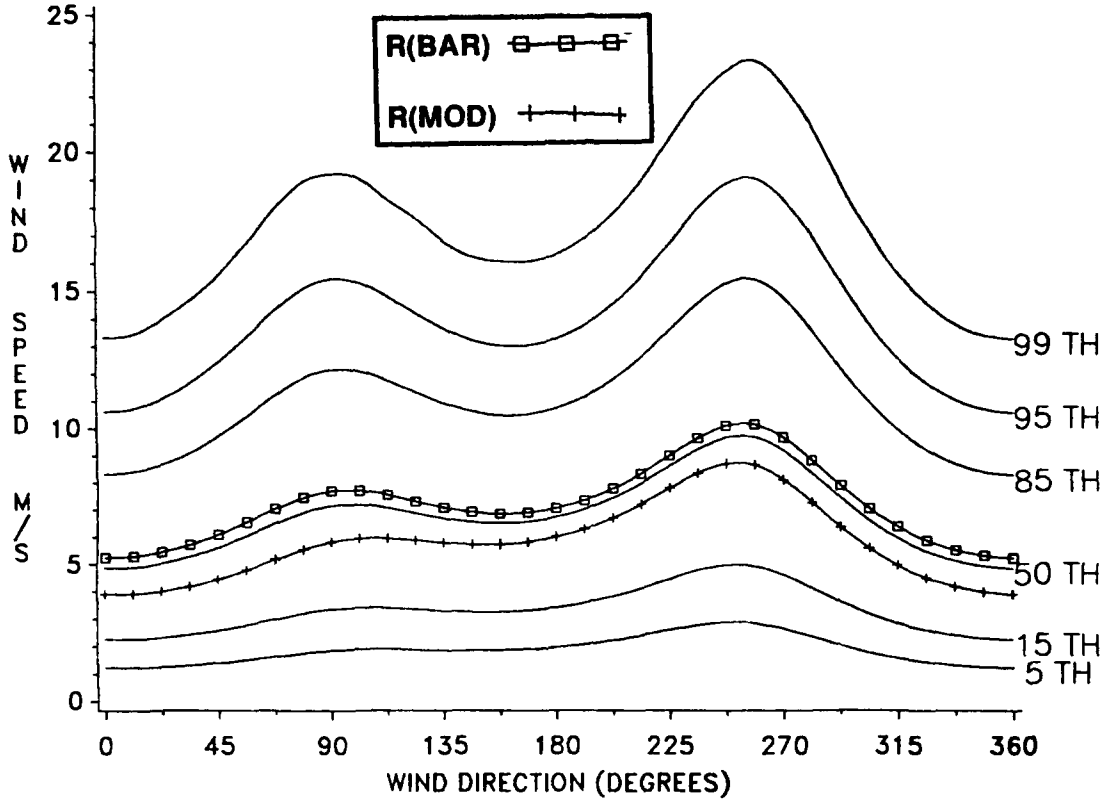

Figure E-65. Conditional Wind Speed Given Direction, July, 4 KM.

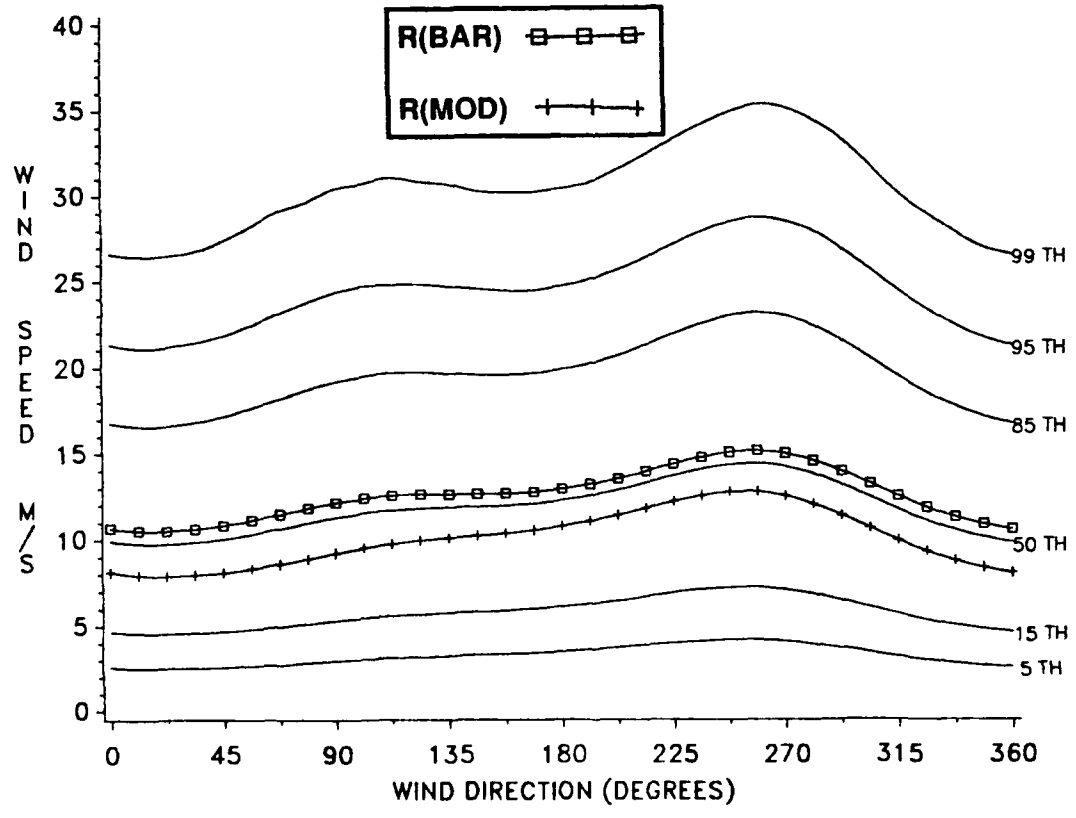

Figure E-66. Conditional Wind Speed Given Direction, July, 8 KM.

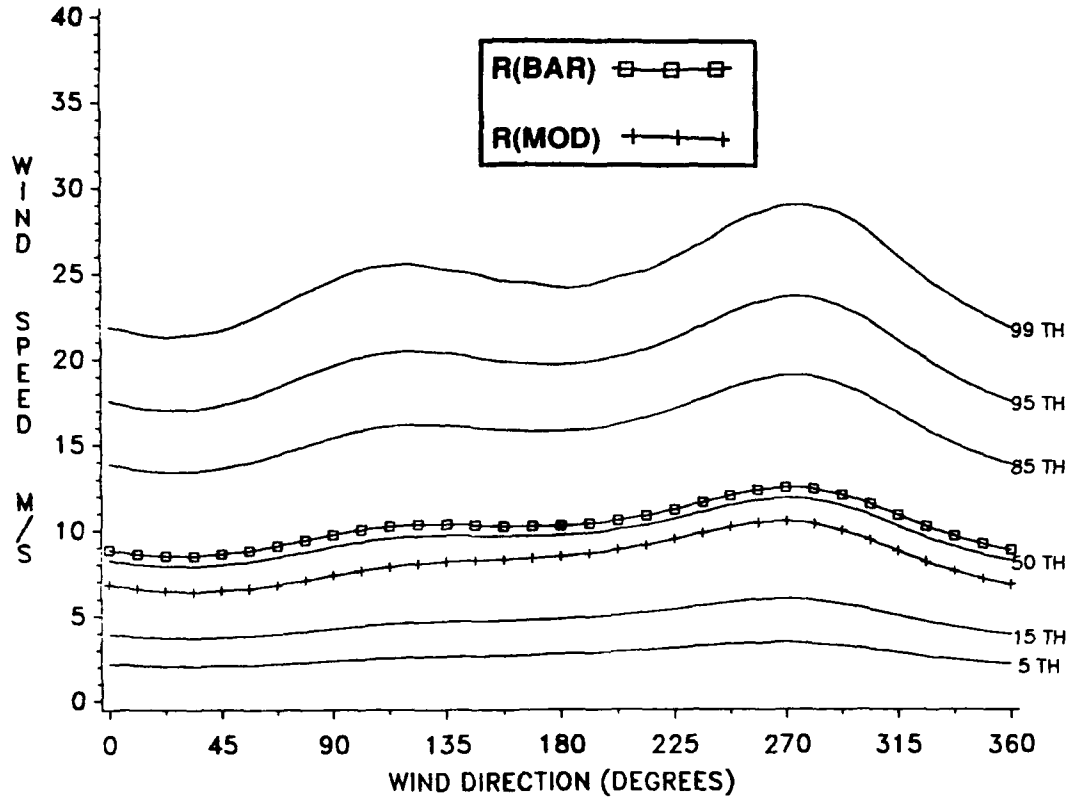

Figure E-67. Conditional Wind Speed Given Direction, July, 12 KM.

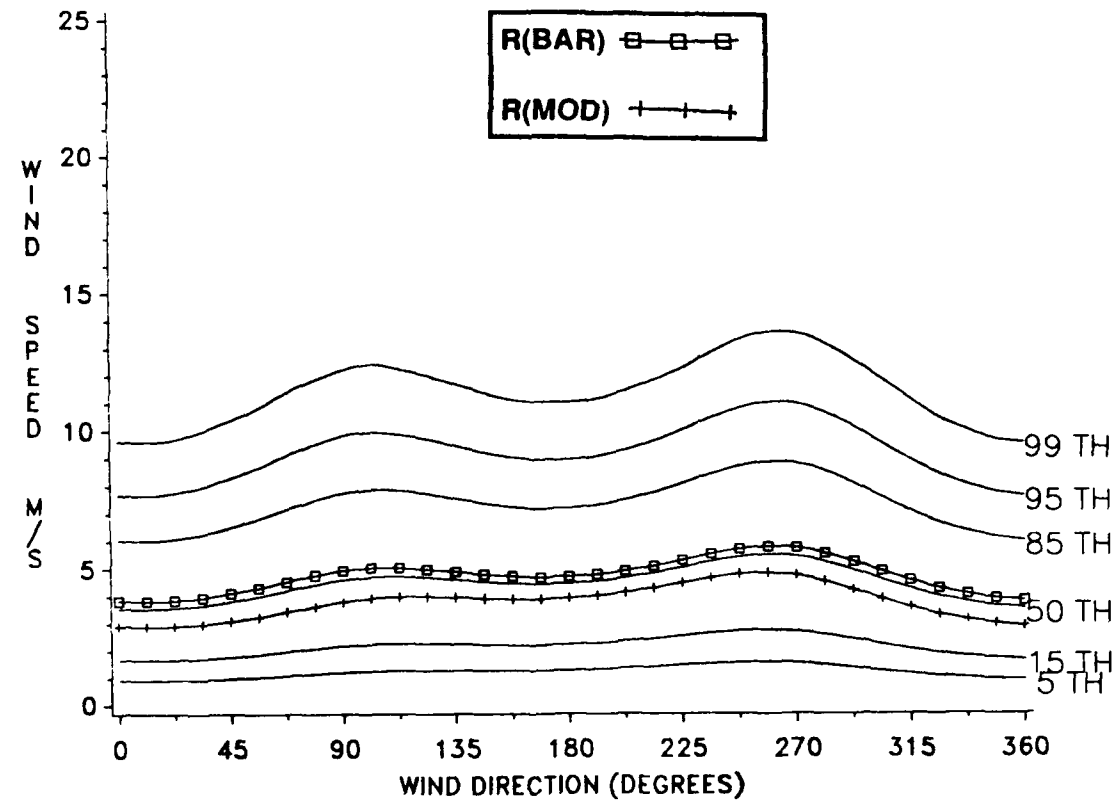

Figure E-68. Conditional Wind Speed Given Direction, July, 16 KM.

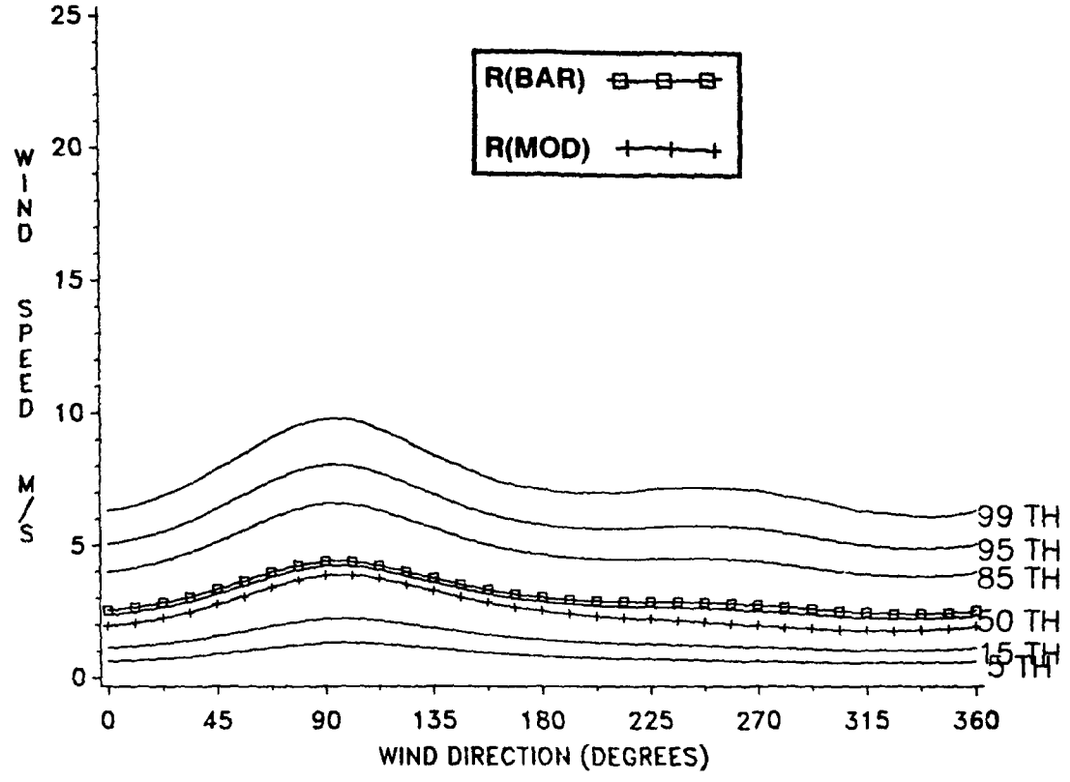

Figure E-69. Conditional Wind Speed Given Direction, July, 20 KM.

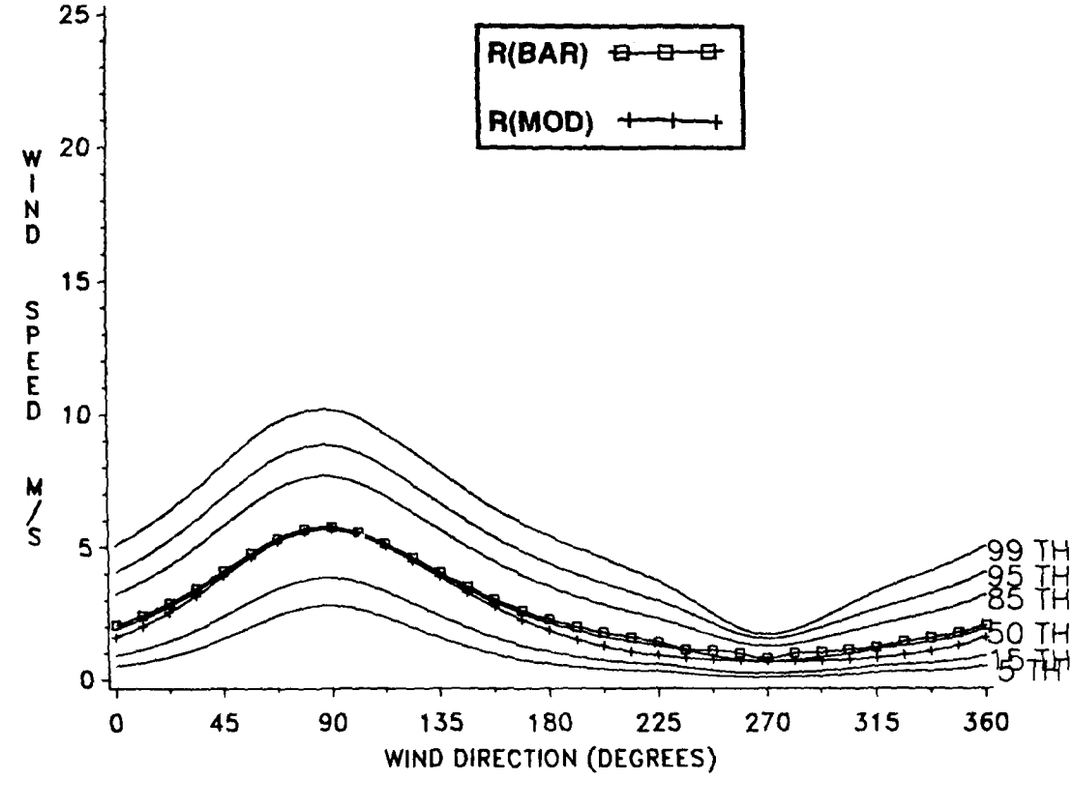

Figure E-70. Conditional Wind Speed Given Direction, July, 24 KM.

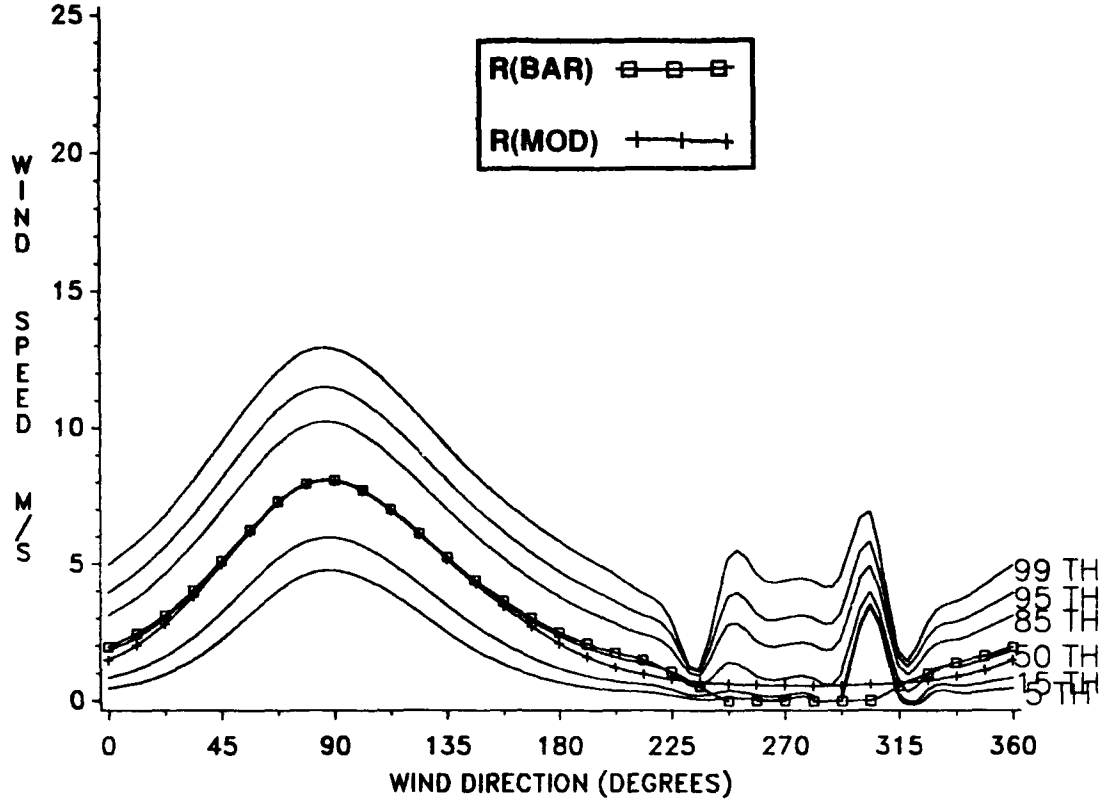

Figure E-71. Conditional Wind Speed Given Direction, July, 28 KM.

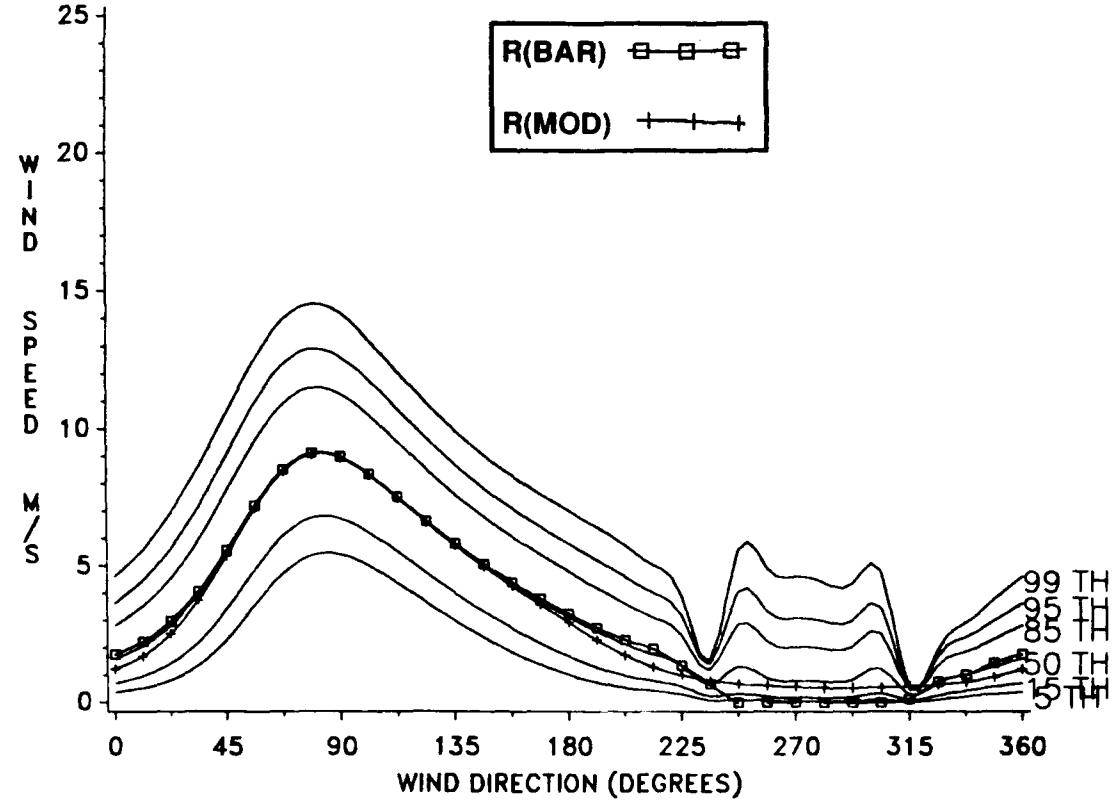

Figure E-72. Conditional Wind Speed Given Direction, July, 30 KM.

APPENDIX F

Thermodynamic Statistics Derivable from Appendix B, C, and D Tables

This appendix gives graphic examples of certain pressure, density, and virtual temperature statistics that can be derived from basic data in Appendices B, C, and D. These examples should help RRA users in understanding and visualizing the relationships that can be inferred from data in Appendices B and D.

Monthly Means from the Annual Mean.
The hydrostatic model values in Appendix D are used to compute monthly mean differences relative to annual mean values of pressure, density, and virtual temperature (expressed in percent), and the monthly mean difference in virtual temperature for annual mean virtual temperature (expressed in kelvin, K). Examples of these four statistics are given in Tables F-1 (January) and F-2 (July); graphic displays of the four statistics contained in these tables are then provided by Figures F-1 through F-8. The relative differences between monthly mean values (from Tables D-1 through D-12 for all months) and annual mean values (Table D-13) are illustrated in Figures F-9 and F-18 for pressure, Figures F-10 and F-12 for density, and Figures F-13 and F-14 for virtual temperature. Differences between monthly mean virtual temperature differences and annual mean virtual temperature for all months are given in Figures F-15 and F-16.

Coefficients of Variation and Derived Correlation Coefficients.
The coefficient of variation (C_V) is defined as "the standard deviation with respect to the mean divided by the mean." Coefficients of variation for pressure (C_VP) and density (C_VD) were computed using standard deviations in Appendix B and the hydrostatic mean values in Appendix E. The coefficient of variation for temperature uses the standard deviations of virtual temperature from Appendix C to the altitude at which virtual temperature exists; above that altitude, standard deviations of temperature are from Appendix B. Mean values for virtual temperature to the altitude at which it exists and above are taken from Appendix E. No distinction is made between virtual temperature and temperature in Table F-3, Table F-4, or any of the figures.

From the coefficients of variation for pressure and temperature (virtual temperature to the altitude at which it exists), correlation coefficients between these quantities are derived using Buell's method--see Chapter 3. The three equations for the derived correlation coefficients in Tables F-3 and F-4 are:

$$R(P,T) = \frac{(C_VT)^2 + (C_VP)^2 - (C_VD)^2}{2|C_VT \cdot C_VP|} \qquad \text{(F-1)}$$

$$R(P,D) = \frac{(C_VD)^2 - (C_VT)^2 + (C_VP)^2}{2|C_VD \cdot C_VP|} \qquad \text{(F-2)}$$

$$R(T,D) = \frac{(C_V P)^2 - (C_V D)^2 - (C_V T)^2}{2[C_V T \cdot C_V D]} \qquad \text{(F-3)}$$

To test for validity of derived correlation coefficients, all three of the following inequalities must be satisfied:

$$\begin{aligned} C_V P - (C_V D + C_V T) &< 0 \\ C_V D - (C_V T + C_V P) &< 0 \\ C_V T - (C_V P + C_V D) &< 0 \end{aligned} \qquad \text{(F-4)}$$

In the examples (Tables F-3 and F-4), the numerical values from equation F-4 are usually negative, and the derived correlation test is considered valid. However, when any of the inequalities are not satisfied, "9.999" (missing) is written in the table. The rare exceptions to this test for several RRAs occur at extremely high altitudes where sample sizes for the statistical sample are small.

Statistical parameters from Table F-3 (January) and Table F-4 (July) are illustrated in Figures F-17 through F-20.

$C_V P$ values for all months are given in Figures F-21 and F-22. $C_V D$ values are given in Figures F-23 and F-24, and $C_V T$ values in Figures F-25 and F-26. If the abscissa on the figures for the coefficient of variation is multiplied by 100, these figures would show the percentage of random dispersion for these quantities over the month with respect to the monthly mean.

Derived correlation coefficients for all months are shown as follows: Figures F-27 and F-28 give *R(P,D)*; Figures F-29 and F-30 give *R(P,T)*; and Figures F-31 and F-32 give *R(T,D)*.

TABLE F-1. Deltas in Percent Relative to Annual, Fairbanks, January.

RLEVEL	PRESSURE	DENSITY	TEMP.	TMO-TANN(K)
0.000	0.236	7.336	-6.617	-18.070
0.135	0.124	6.843	-6.290	-17.150
1.000	-0.352	2.708	-2.981	-8.100
2.000	-0.655	1.195	-1.828	-4.880
3.000	-0.888	0.799	-1.675	-4.370
4.000	-1.116	0.627	-1.732	-4.410
5.000	-1.353	0.314	-1.662	-4.130
6.000	-1.609	0.189	-1.793	-4.380
7.000	-1.880	-0.312	-1.571	-3.790
8.000	-2.172	-1.472	-0.710	-1.690
9.000	-2.406	5.413	-7.418	-17.540
10.000	-2.635	6.176	-8.296	-19.660
11.000	-2.850	10.861	-12.367	-30.830
12.000	-3.038	10.897	-12.564	-31.610
13.000	-3.218	11.341	-13.075	-33.200
14.000	-3.406	12.088	-13.825	-35.430
15.000	-3.589	13.041	-14.712	-38.060
16.000	-3.938	13.811	-15.597	-40.740
17.000	-4.130	14.928	-16.583	-43.750
18.000	-4.298	16.007	-17.502	-46.670
19.000	-4.516	17.179	-18.516	-49.950
20.000	-4.586	18.577	-19.534	-53.380
21.000	-4.745	16.663	-18.348	-49.400
22.000	-4.845	13.553	-16.199	-42.500
23.000	-4.974	9.503	-13.219	-33.520
24.000	-5.066	5.518	-10.032	-24.590
25.000	-5.200	-4.165	-1.079	-2.410
26.000	-5.130	-4.145	-1.027	-2.300
27.000	-5.321	-4.274	-1.094	-2.460
28.000	-5.453	-4.358	-1.147	-2.590
29.000	-5.543	-4.312	-1.286	-2.920
30.000	-5.527	-4.062	-1.524	-3.480

TABLE F-2. Deltas in Percent Relative to Annual, Fairbanks, July.

RLEVEL	PRESSURE	DENSITY	TEMP.	TMO-TANN(K)
0.000	0.075	-6.439	6.962	19.010
0.135	0.190	-6.162	6.767	18.450
1.000	0.798	-4.045	5.045	13.710
2.000	1.368	-2.607	4.080	10.890
3.000	1.890	-1.962	3.930	10.250
4.000	2.441	-1.625	4.132	10.520
5.000	2.993	-1.119	4.161	10.340
6.000	3.637	0.431	3.193	7.800
7.000	4.263	2.736	1.489	3.590
8.000	4.970	4.828	0.134	0.320
9.000	5.490	5.493	-0.004	-0.010
10.000	5.831	3.259	2.494	5.910
11.000	5.959	5.959	0.000	0.000
12.000	5.984	5.984	0.000	0.000
13.000	6.111	6.111	0.000	0.000
14.000	6.248	6.248	0.000	0.000
15.000	6.419	6.419	0.000	0.000
16.000	6.375	6.375	0.000	0.000
17.000	6.724	6.724	0.000	0.000
18.000	6.917	6.917	0.000	0.000
19.000	7.138	7.138	0.000	0.000
20.000	7.419	7.419	0.000	0.000
21.000	7.684	7.684	0.000	0.000
22.000	8.051	8.051	0.000	0.000
23.000	8.417	8.417	0.000	0.000
24.000	8.617	8.617	0.000	0.000
25.000	9.070	5.867	3.027	6.760
26.000	9.358	5.890	3.273	7.330
27.000	9.478	5.806	3.469	7.800
28.000	9.860	5.960	3.679	8.310
29.000	10.120	6.049	3.840	8.720
30.000	10.449	6.190	4.012	9.160

TABLE F-3. Coefficients of Variation/Correlation Coefficients, January.

LEVEL	CVP	CVD	CVT	R(P,T)	R(P,D)	R(T,D)
0.000	0.015	0.046	0.038	-0.365	0.623	-0.956
0.135	0.014	0.044	0.037	-0.324	0.600	-0.951
1.000	0.014	0.037	0.033	-0.076	0.446	-0.927
2.000	0.015	0.027	0.027	0.285	0.261	-0.851
3.000	0.016	0.021	0.024	0.534	0.147	-0.758
4.000	0.018	0.018	0.025	0.674	0.095	-0.671
5.000	0.021	0.016	0.026	0.707	0.318	-0.446
6.000	0.024	0.015	0.026	0.772	0.699	0.085
7.000	0.027	0.015	0.024	9.999	9.999	9.999
8.000	0.030	0.020	0.019	9.999	9.999	9.999
9.000	0.032	0.030	0.016	0.360	0.859	-0.168
10.000	0.031	0.043	0.023	-0.213	0.853	-0.692
11.000	0.031	0.046	0.027	-0.297	0.831	-0.778
12.000	0.030	0.040	0.024	-0.106	0.803	-0.678
13.000	0.030	0.035	0.023	0.129	0.769	-0.535
14.000	0.031	0.033	0.023	0.281	0.745	-0.431
15.000	0.032	0.032	0.024	0.372	0.716	-0.381
16.000	0.034	0.032	0.025	0.428	0.704	-0.340
17.000	0.035	0.032	0.027	0.513	0.676	-0.286
18.000	0.037	0.032	0.029	0.561	0.660	-0.252
19.000	0.040	0.032	0.031	0.610	0.649	-0.207
20.000	0.041	0.032	0.033	0.635	0.624	-0.208
21.000	0.044	0.033	0.035	0.662	0.617	-0.181
22.000	0.047	0.034	0.038	0.698	0.604	-0.149
23.000	0.050	0.035	0.040	0.723	0.601	-0.118
24.000	0.054	0.036	0.042	0.748	0.622	-0.055
25.000	0.057	0.037	0.044	0.756	0.647	-0.010
26.000	0.059	0.038	0.044	0.766	0.668	0.033
27.000	0.064	0.040	0.045	0.775	0.710	0.106
28.000	0.069	0.044	0.046	0.775	0.749	0.161
29.000	0.074	0.048	0.047	0.771	0.781	0.205
30.000	0.072	0.046	0.046	0.775	0.774	0.200

TABLE F-4. Coefficients of Variation/Correlation Coefficient, July.

LEVEL	CVP	CVD	CVT	R(P,T)	R(P,D)	R(T,D)
0.000	0.006	0.018	0.016	-0.082	0.386	-0.951
0.135	0.006	0.017	0.016	-0.039	0.362	-0.946
1.000	0.006	0.013	0.013	0.175	0.250	-0.909
2.000	0.006	0.011	0.012	0.426	0.108	-0.853
3.000	0.007	0.008	0.011	0.617	0.028	-0.769
4.000	0.008	0.008	0.011	0.718	-0.031	-0.718
5.000	0.009	0.008	0.012	0.783	-0.101	-0.698
6.000	0.011	0.008	0.014	0.823	-0.116	-0.660
7.000	0.012	0.008	0.015	0.836	-0.069	-0.606
8.000	0.014	0.009	0.016	0.789	0.446	-0.199
9.000	0.016	0.010	0.016	0.771	0.797	0.230
10.000	0.017	0.019	0.013	0.291	0.728	-0.444
11.000	0.017	0.036	0.019	-0.901	0.973	-0.977
12.000	0.016	0.037	0.019	9.999	9.999	9.999
13.000	0.015	0.029	0.013	9.999	9.999	9.999
14.000	0.014	0.024	0.010	9.999	9.999	9.999
15.000	0.014	0.022	0.008	-0.888	0.984	-0.955
16.000	0.012	0.020	0.007	9.999	9.999	9.999
17.000	0.011	0.018	0.006	9.999	9.999	9.999
18.000	0.011	0.017	0.006	9.999	9.999	9.999
19.000	0.010	0.016	0.005	-0.997	1.000	-0.999
20.000	0.010	0.015	0.005	-0.857	0.984	-0.935
21.000	0.010	0.015	0.005	-0.755	0.971	-0.890
22.000	0.010	0.015	0.005	-0.898	0.989	-0.954
23.000	0.010	0.012	0.005	-0.029	0.889	-0.483
24.000	0.011	0.011	0.006	0.192	0.867	-0.323
25.000	0.011	0.010	0.006	0.387	0.837	-0.180
26.000	0.011	0.010	0.006	0.449	0.853	-0.084
27.000	0.012	0.011	0.006	0.448	0.840	-0.109
28.000	0.012	0.011	0.007	0.499	0.842	-0.047
29.000	0.013	0.011	0.007	0.506	0.844	-0.037
30.000	0.013	0.011	0.007	0.494	0.832	-0.071

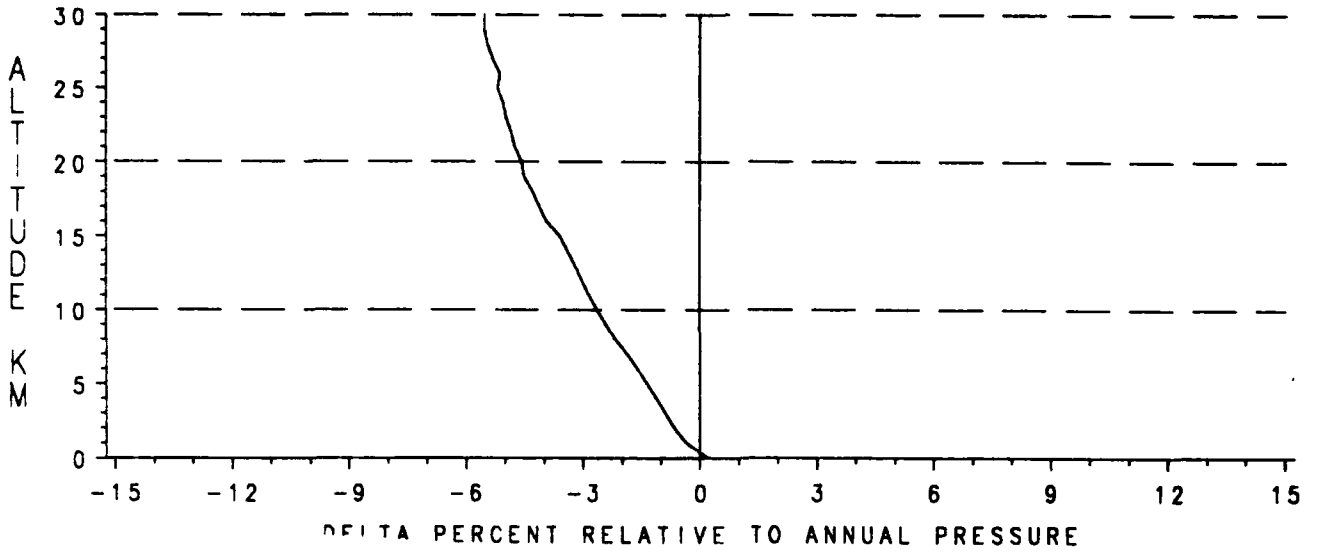

Figure F-1. Delta Percent Relative to Annual Pressure, January

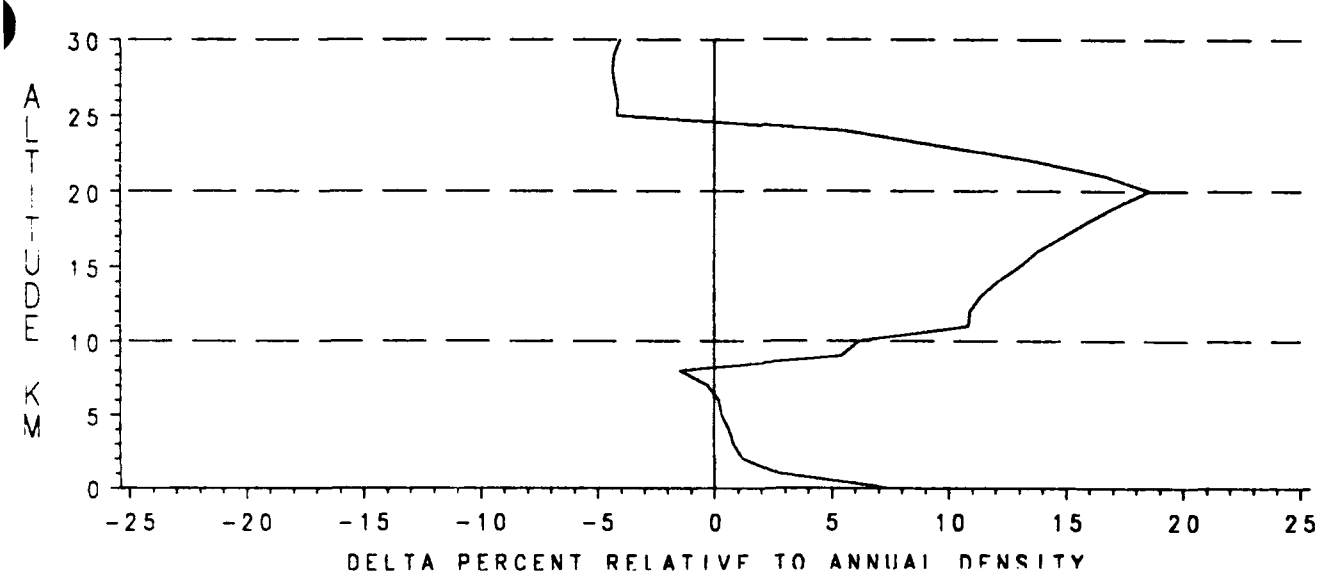

Figure F-2. Delta Percent Relative to Annual Density, January.

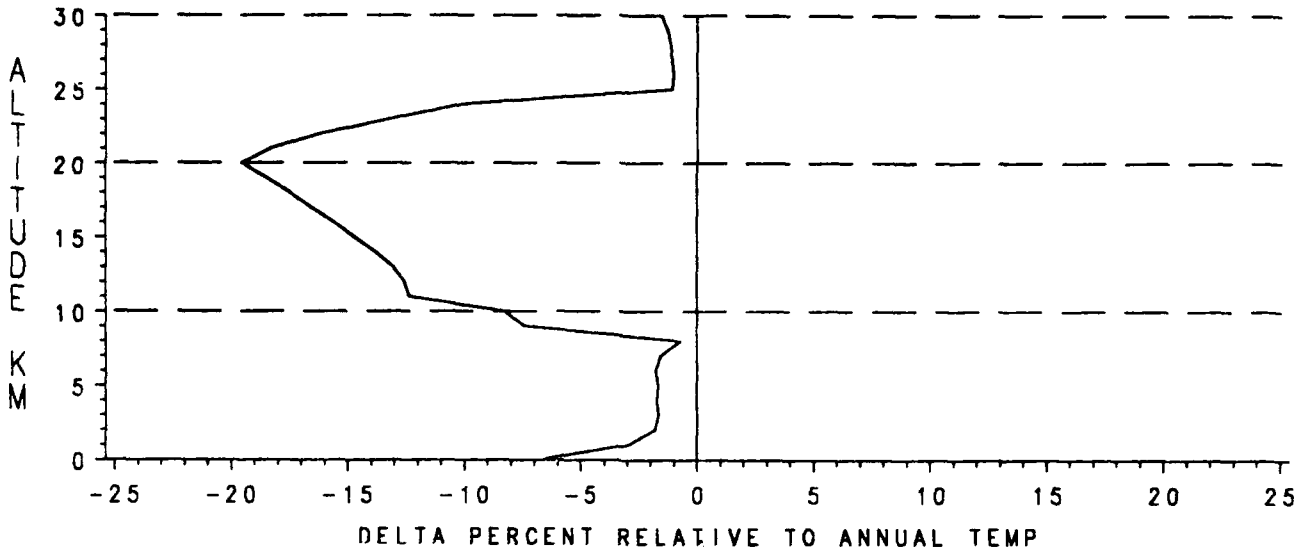

Figure F-3. Delta Percent Relative to Annual Temperature, January

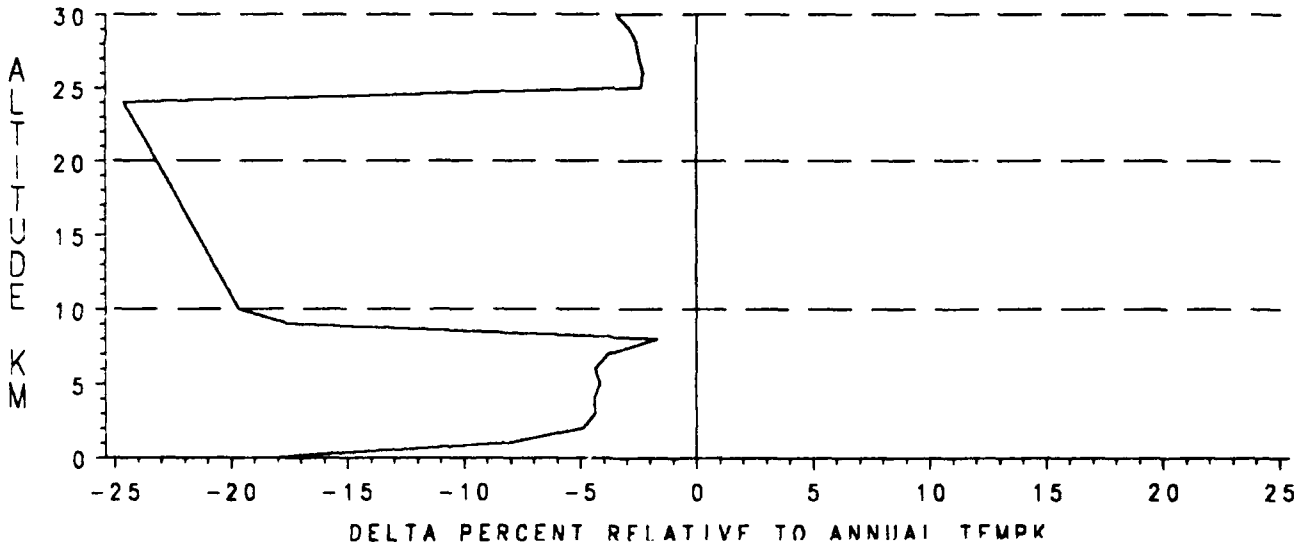

Figure F-4. Delta Temperature (K), January.

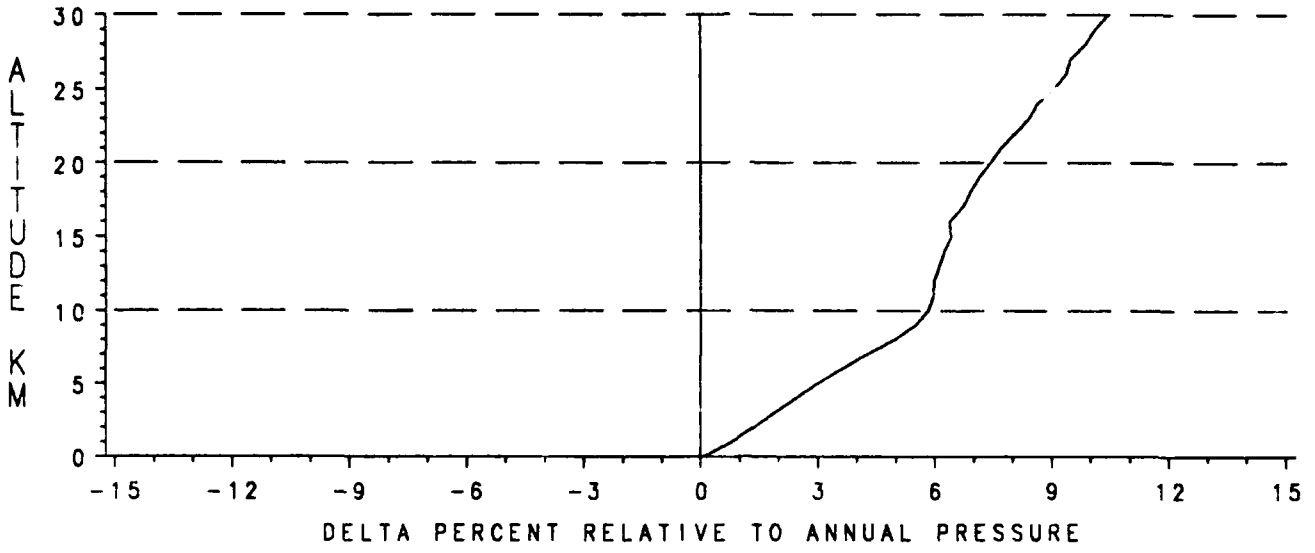

Figure F-5. Delta Percent Relative to Annual Pressure, July.

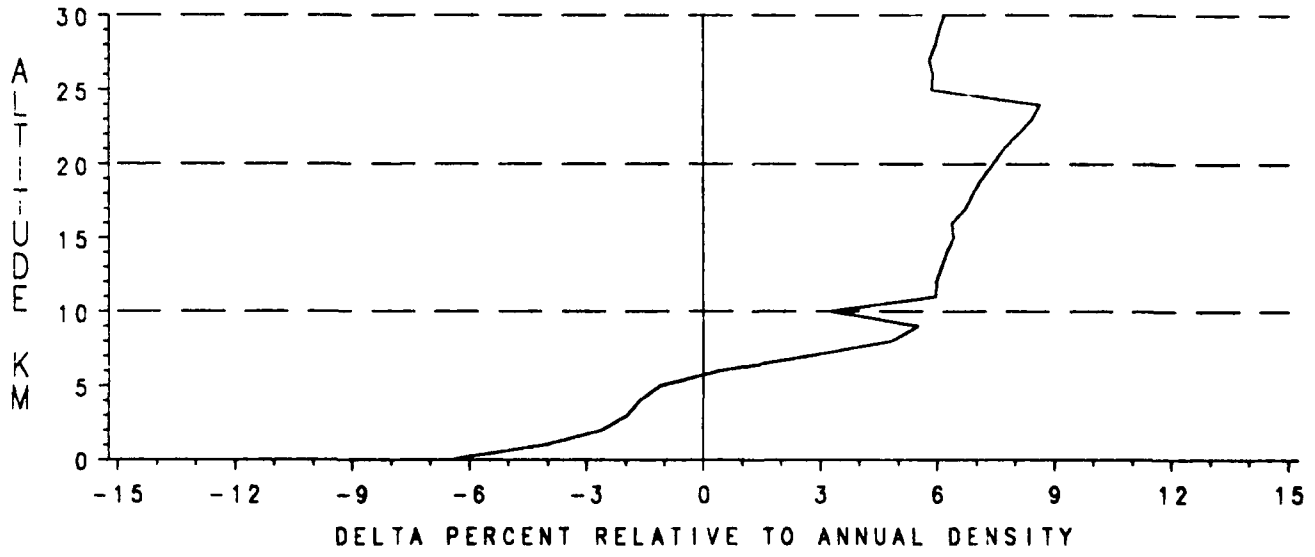

Figure F-6. Delta Percent Relative to Annual Density, July.

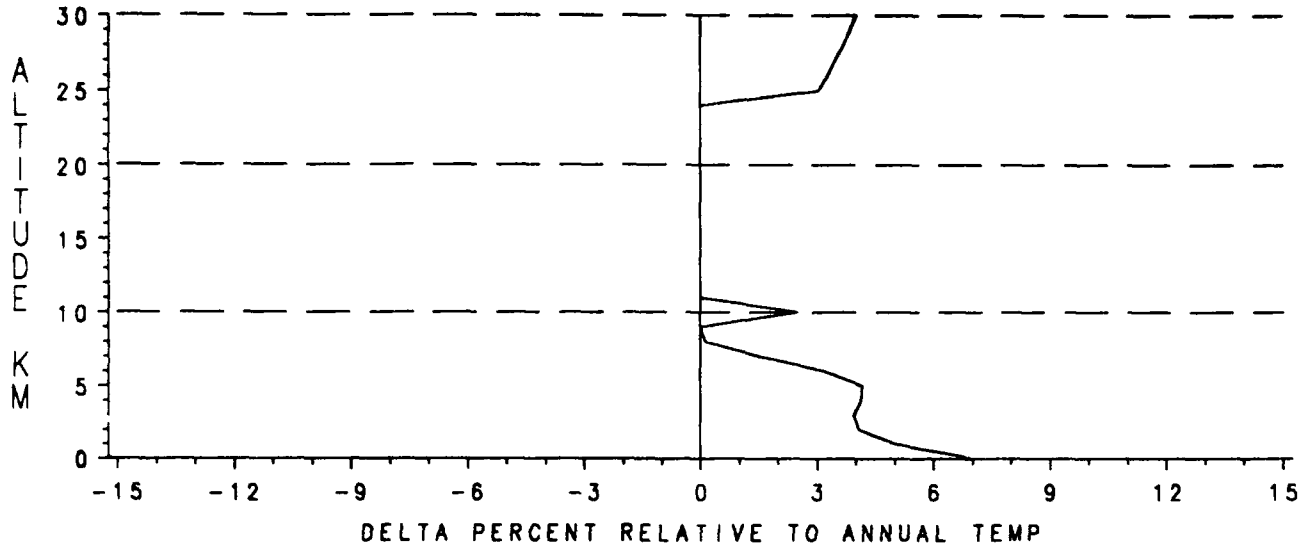

Figure F-7. Delta Percent Relative to Annual Temperature, July.

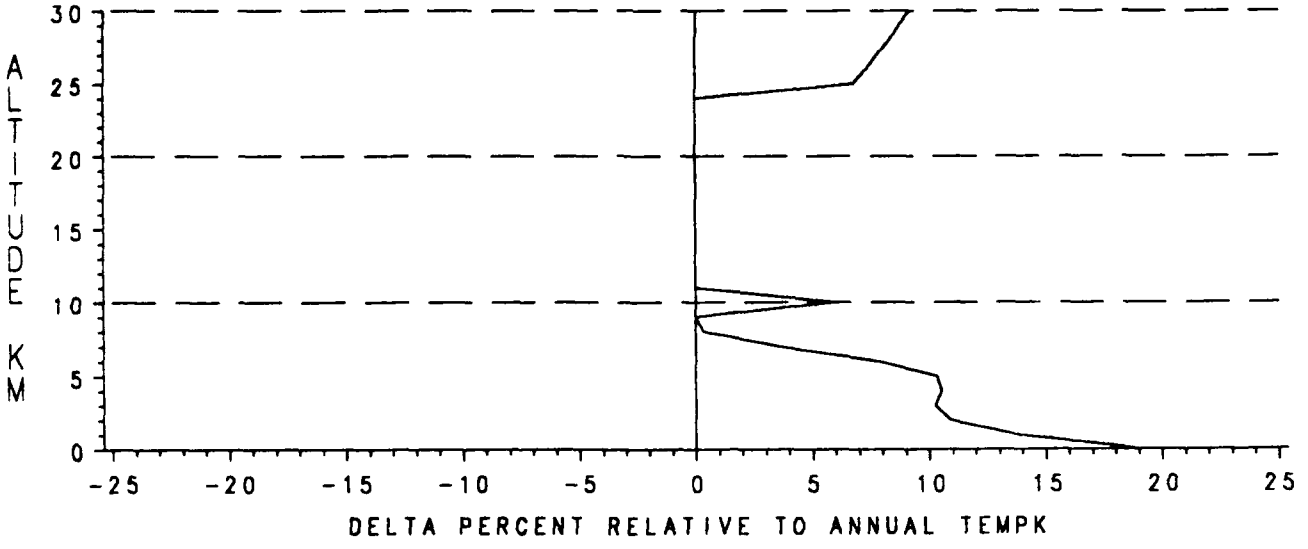

Figure F-8. Delta Temperature (K), July.

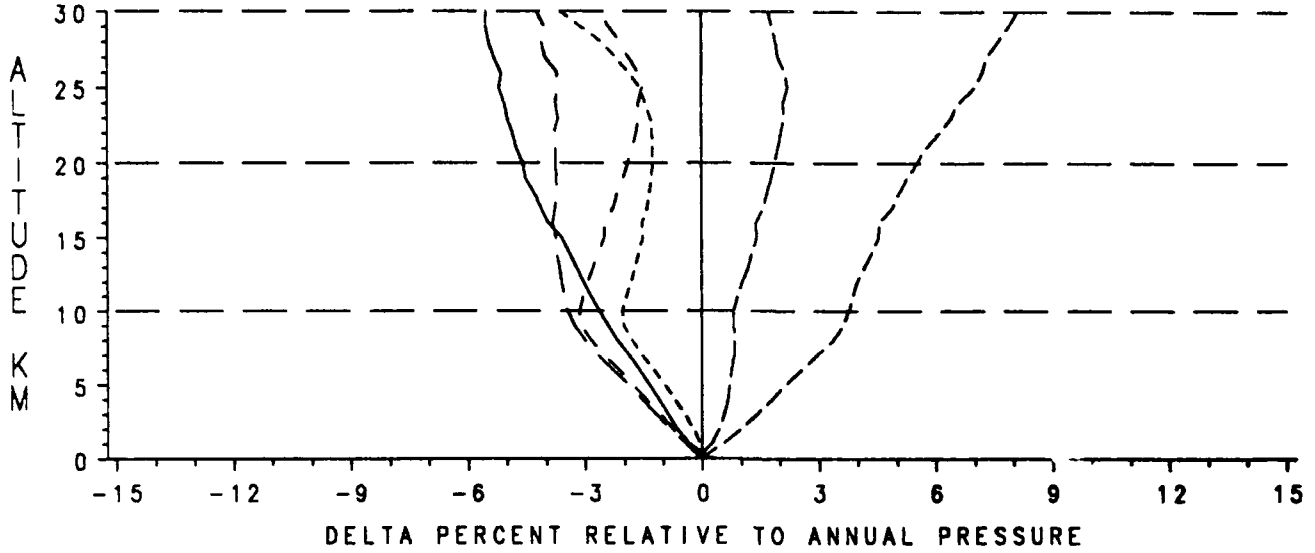

Figure F-9. Delta Percent Relative to Annual Pressure, January-June.

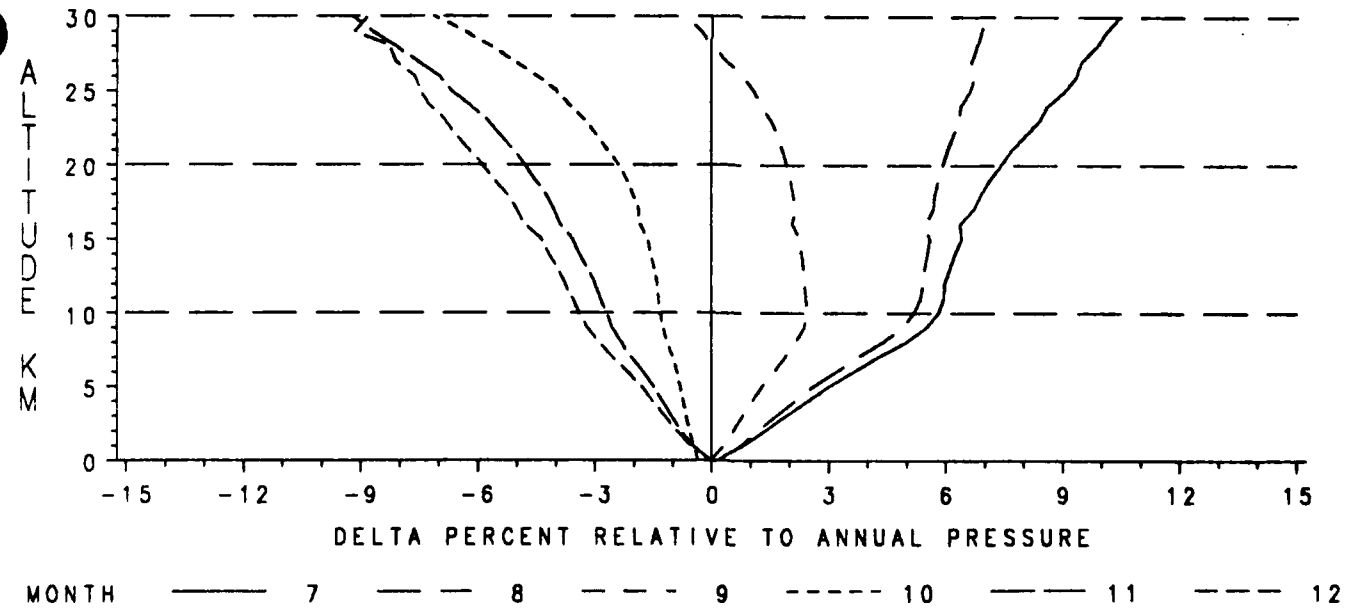

Figure F-10. Delta Percent Relative to Annual Pressure, July-December.

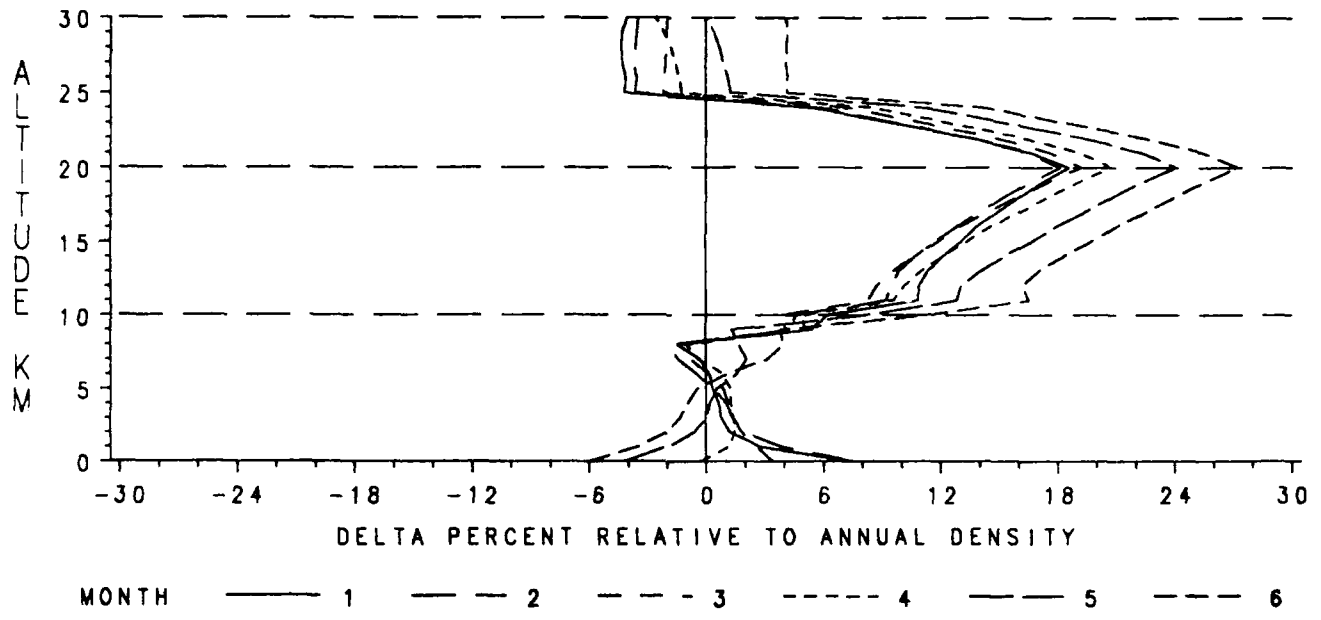

Figure F-11. Delta Percent Relative to Annual Density, January-June.

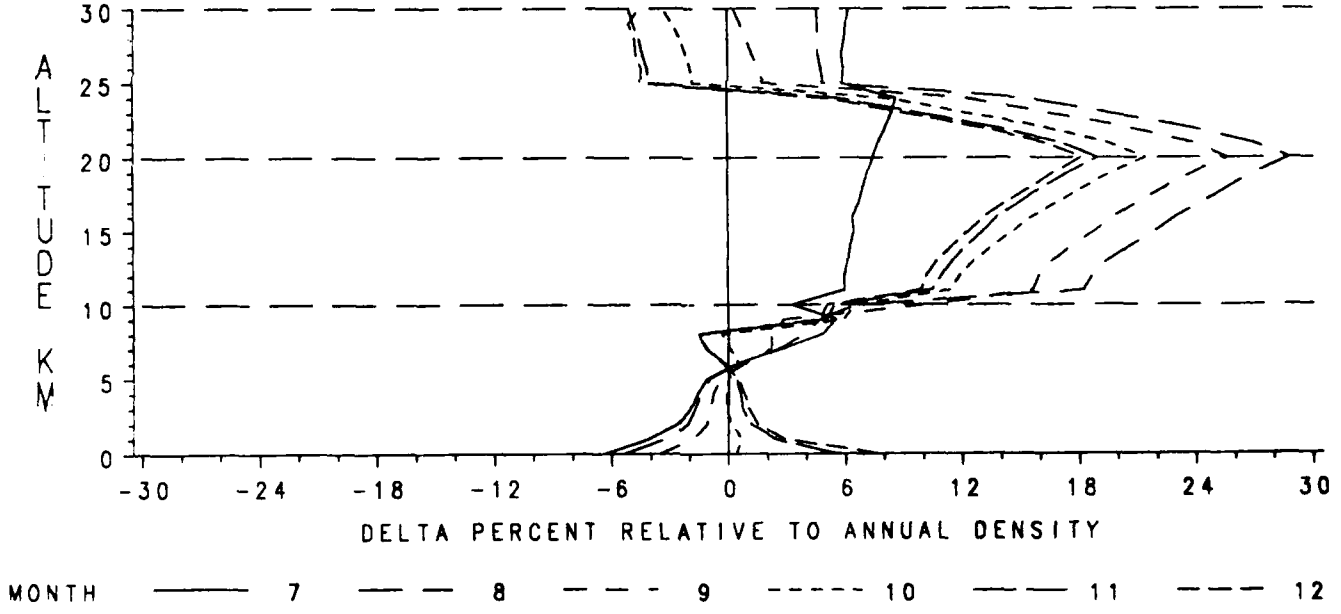

Figure F-12. Delta Percent Relative to Annual Density, July-December.

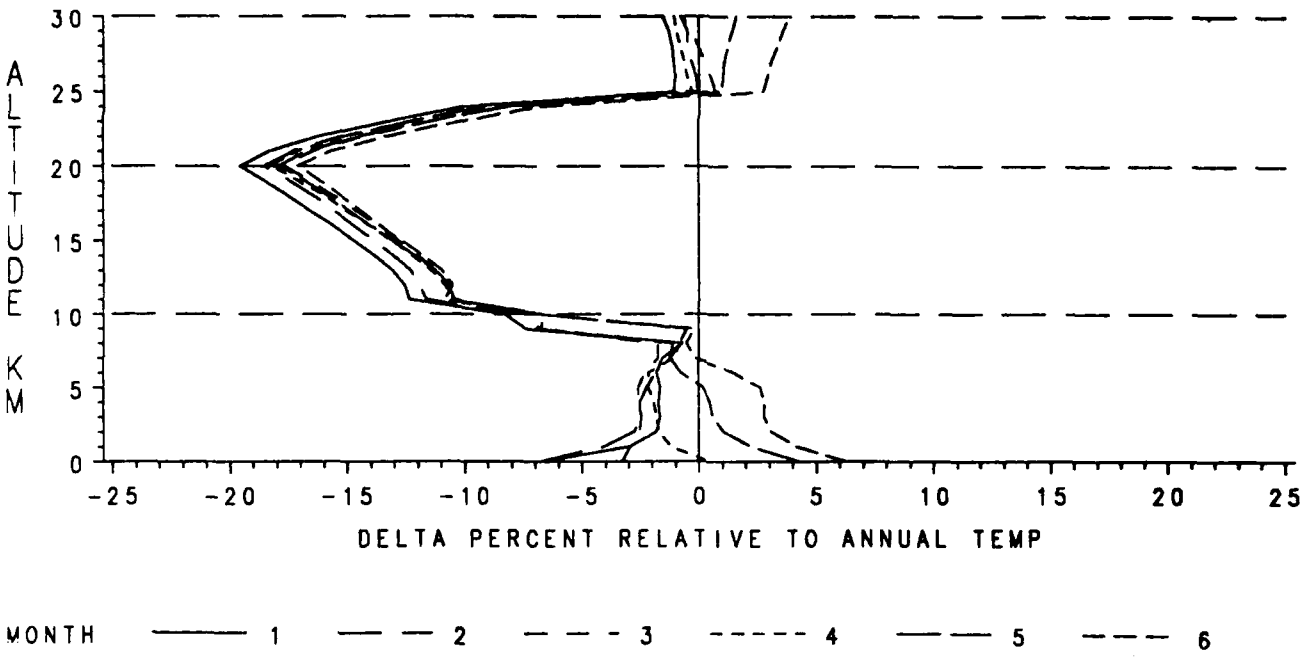

Figure F-13. Delta Percent Relative to Annual Temperature, January-June.

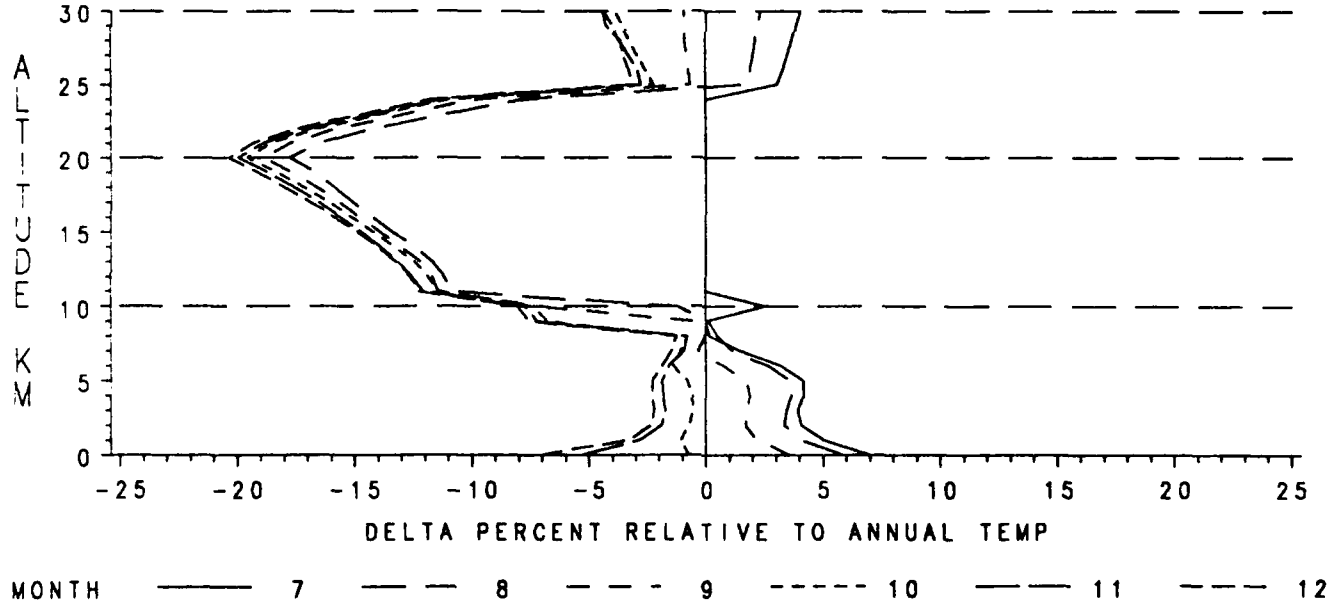

Figure F-14. Delta Percent Relative to Annual Temperature, July-December.

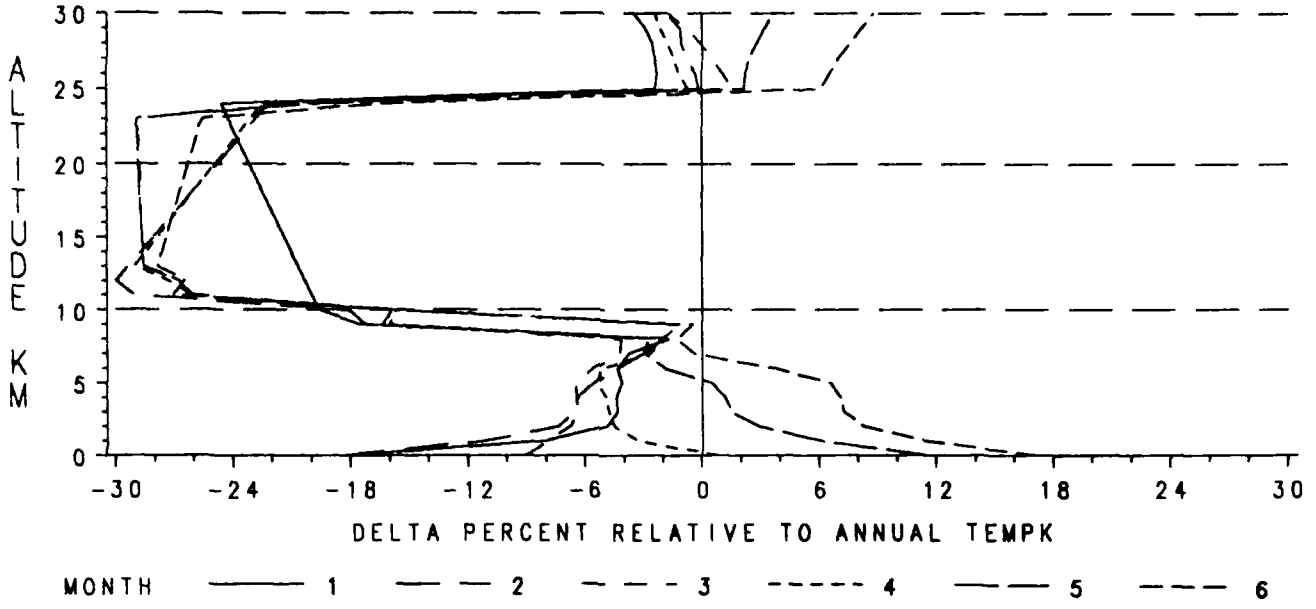

Figure F-15. Delta Temperature (K), January-June.

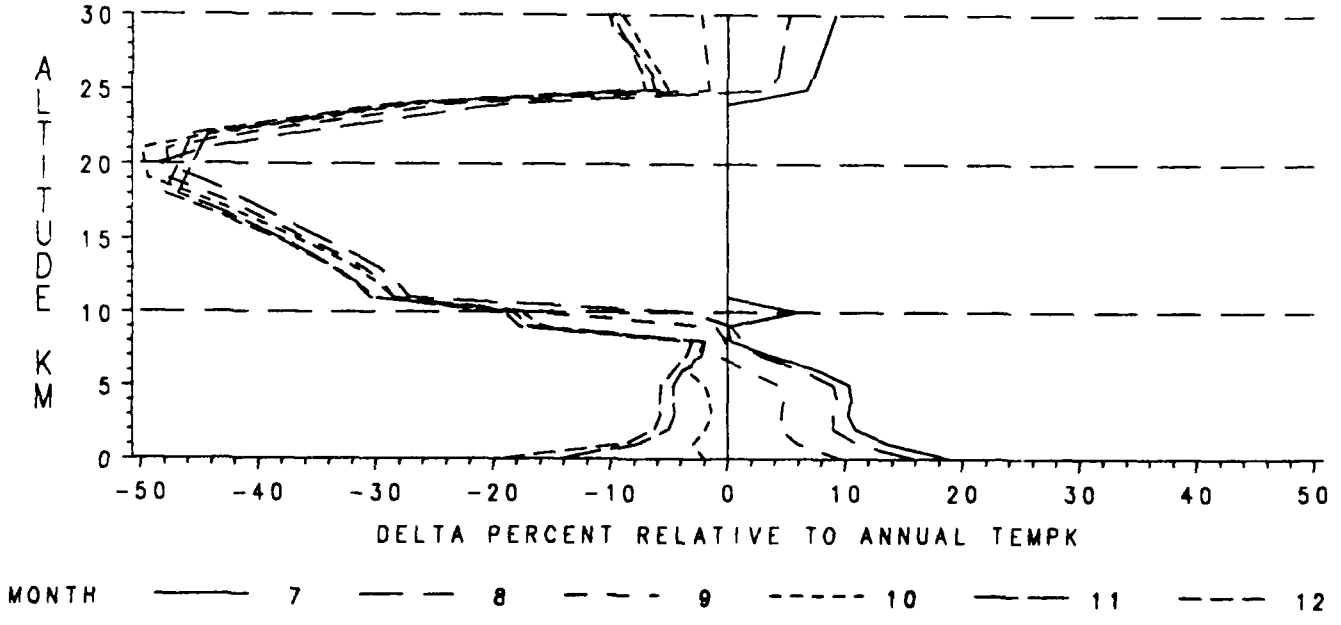

Figure F-16 Delta Temperature (K), July-December.

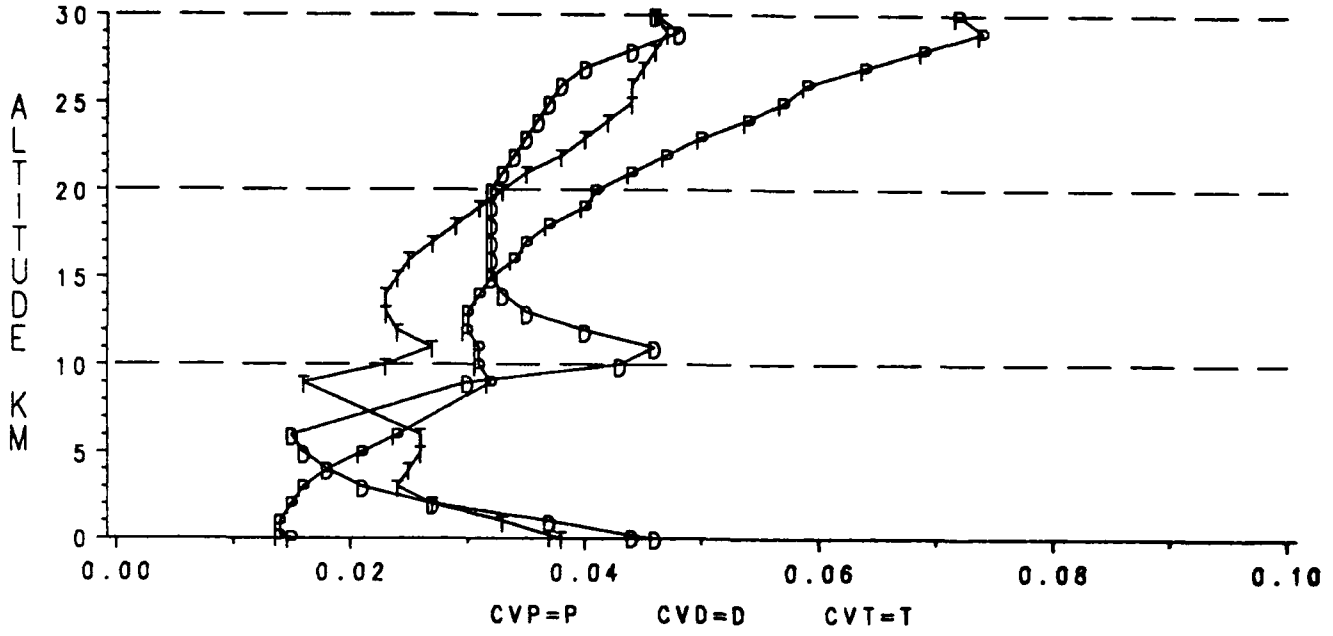

Figure F-17. Coefficients of Variation for Pressure (P), Density (D), and Temperature (T), January.

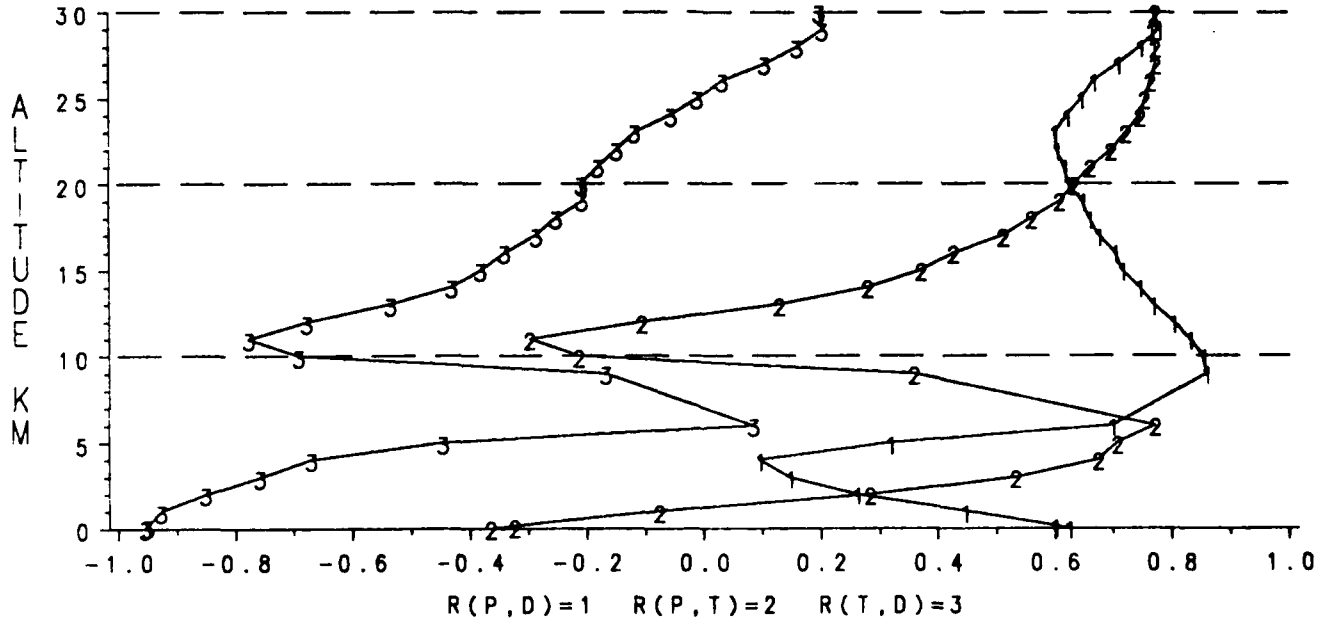

Figure F-18. Correlation Coefficients for P&D, P&T, and T&D, January.

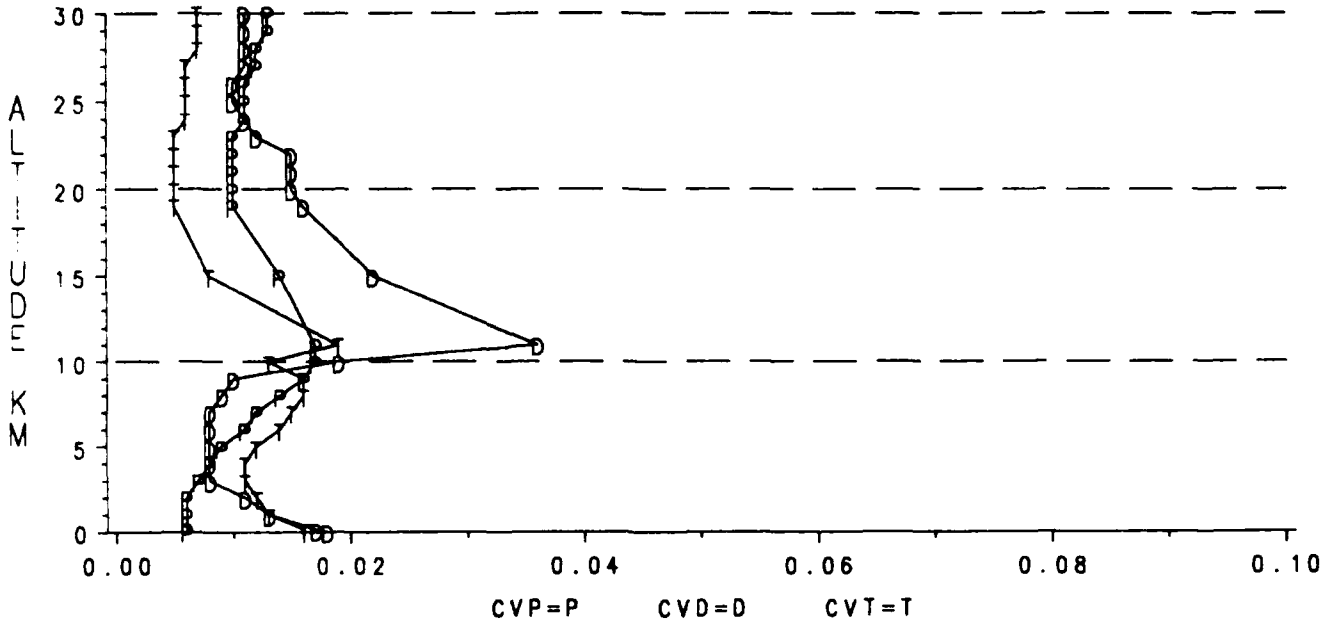

Figure F-19. Coefficients of Variation for Pressure (P), Density (D), and Temperature (T), July.

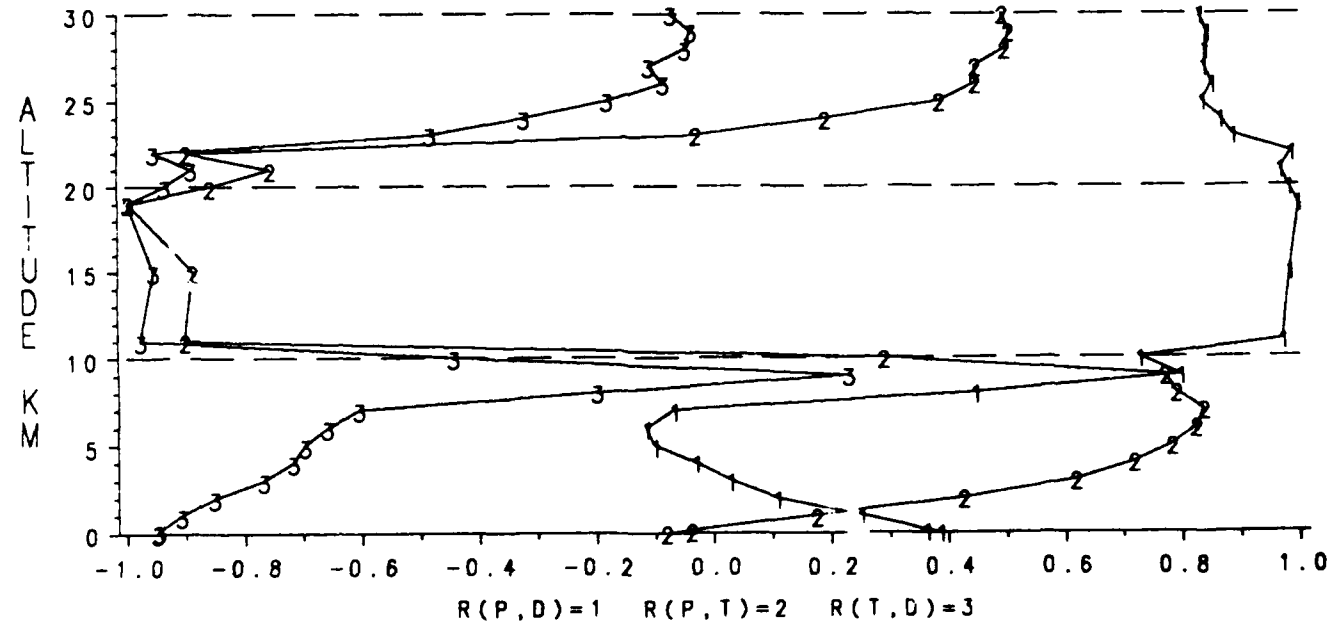

Figure F-20. Correlation Coefficients for P&D, P&T, and T&D, July.

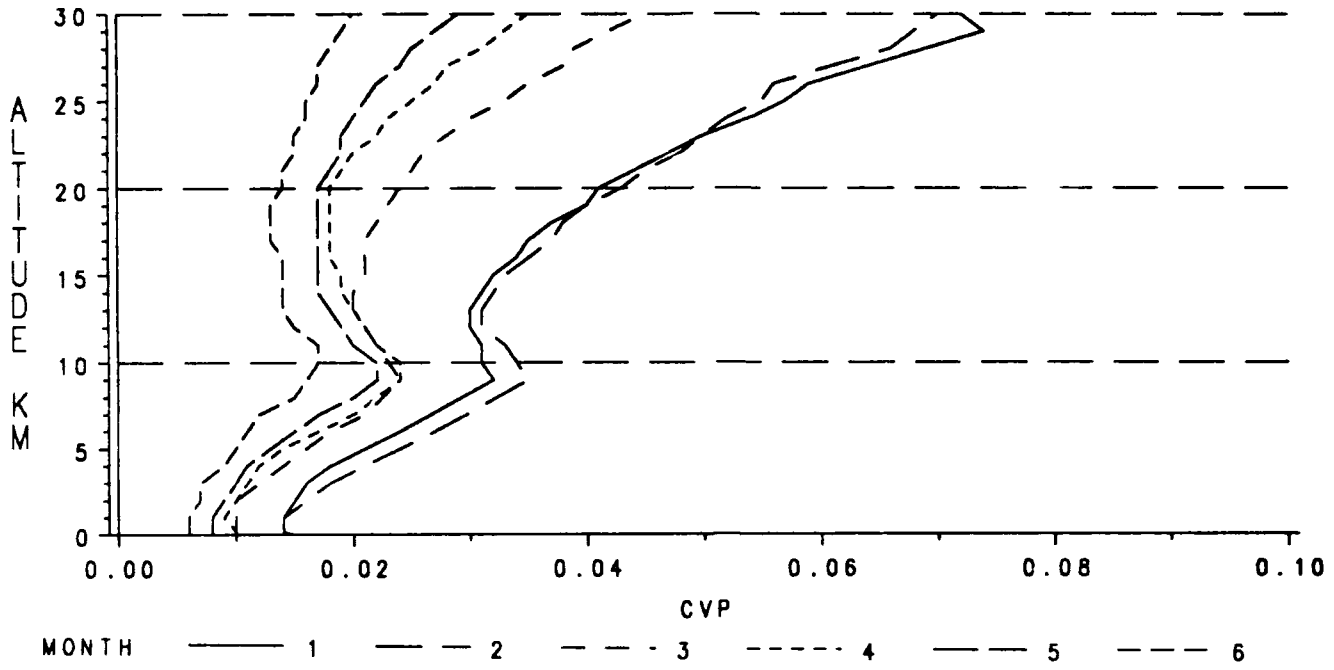

Figure F-21. Coefficients of Variation for Pressure, January-June.

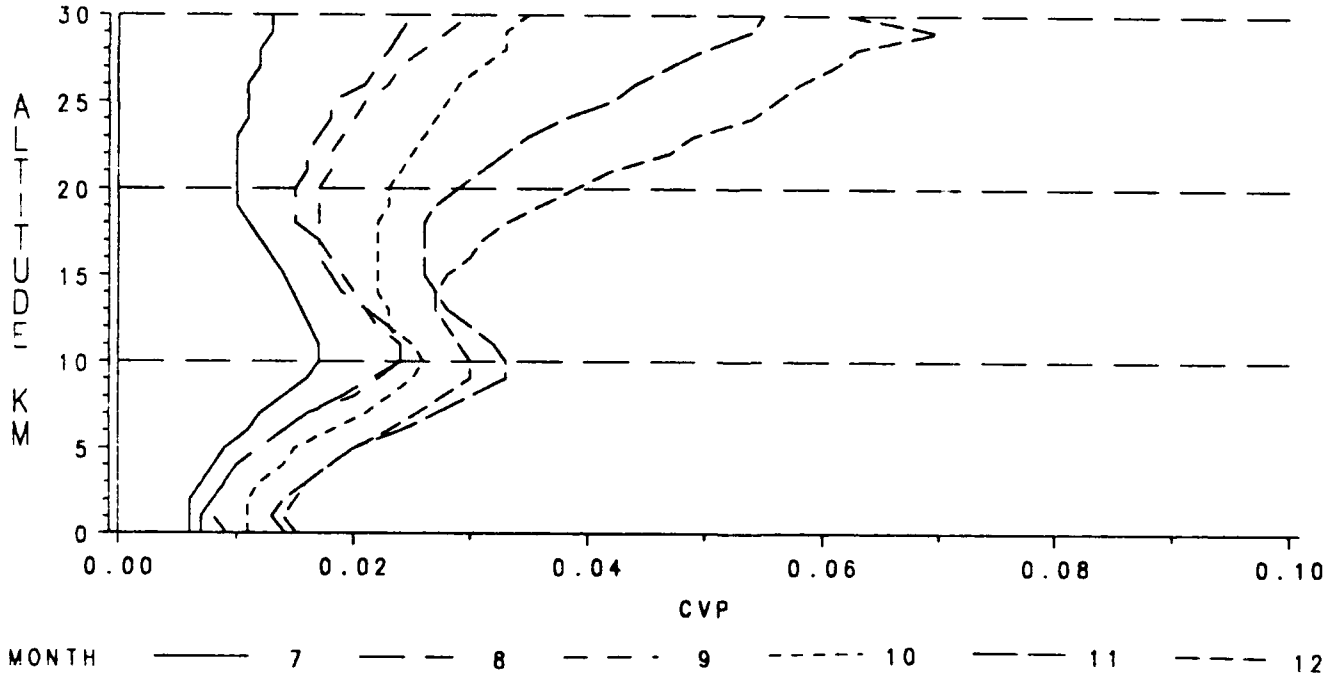

Figure F-22. Coefficients of Variation for Pressure, July-December.

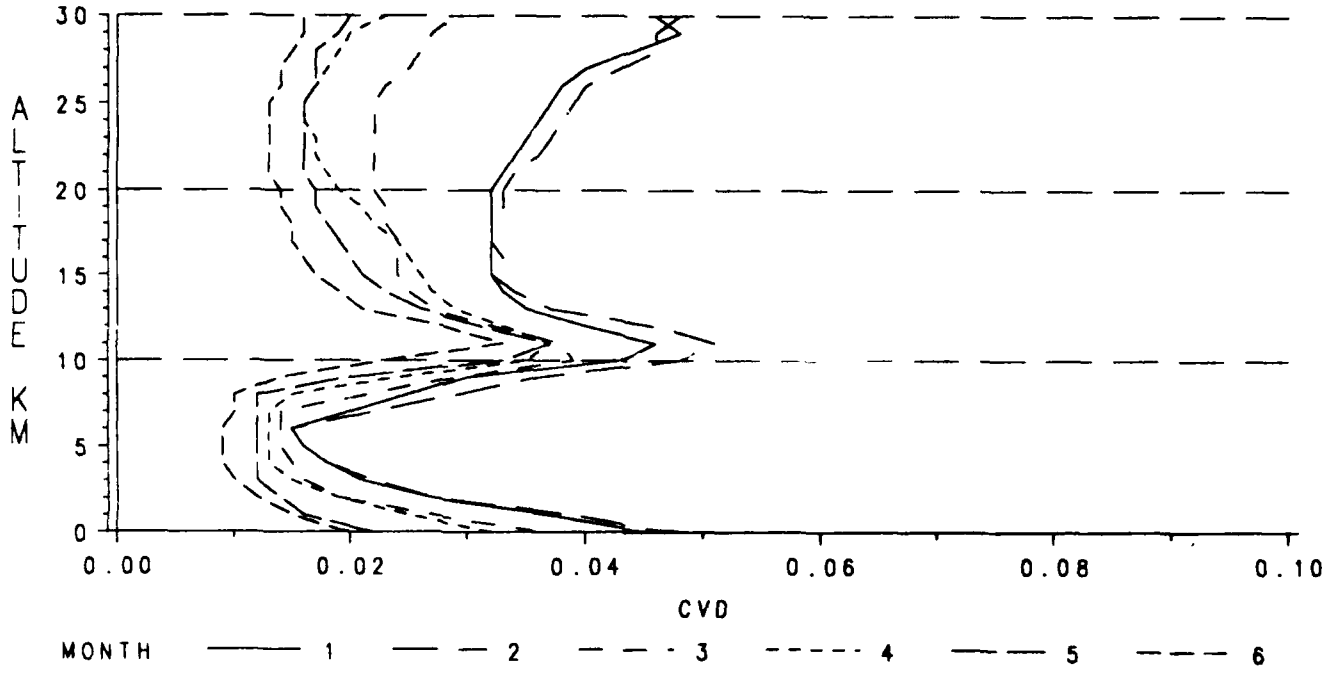

Figure F-23. Coefficients of Variation for Density, January-June.

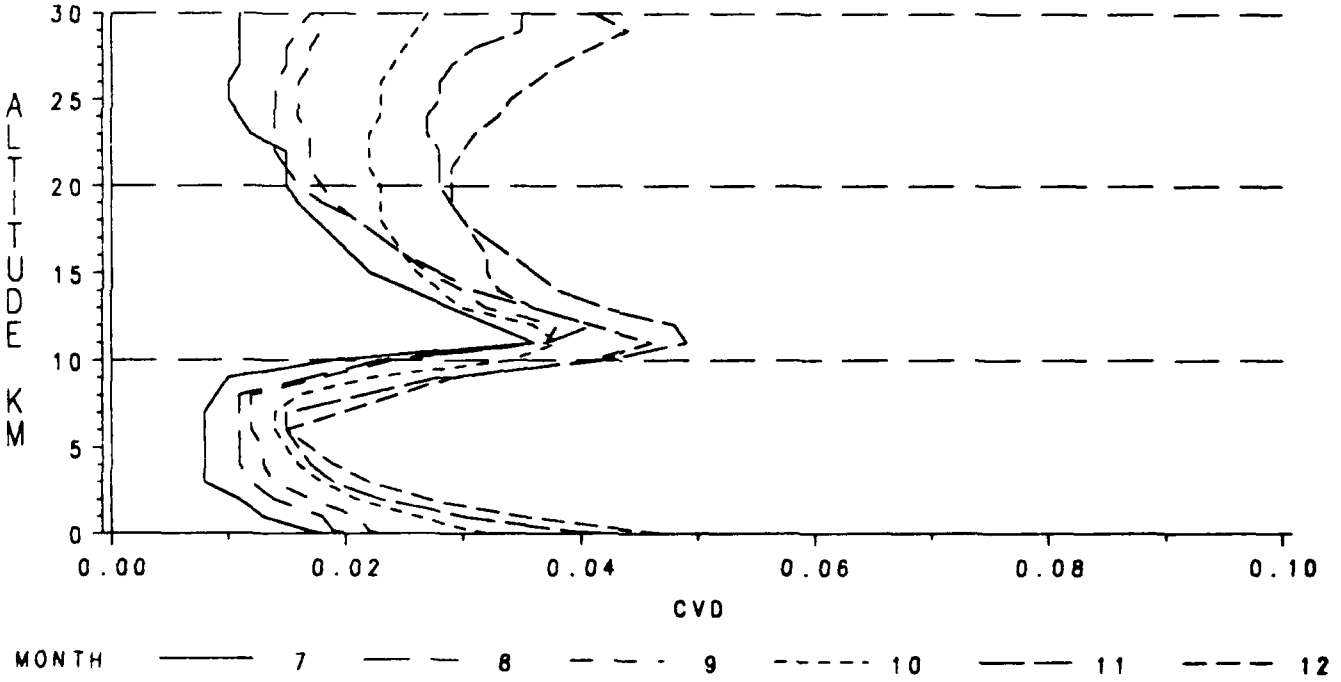

Figure F-24. Coefficients of Variation for Density, July-December.

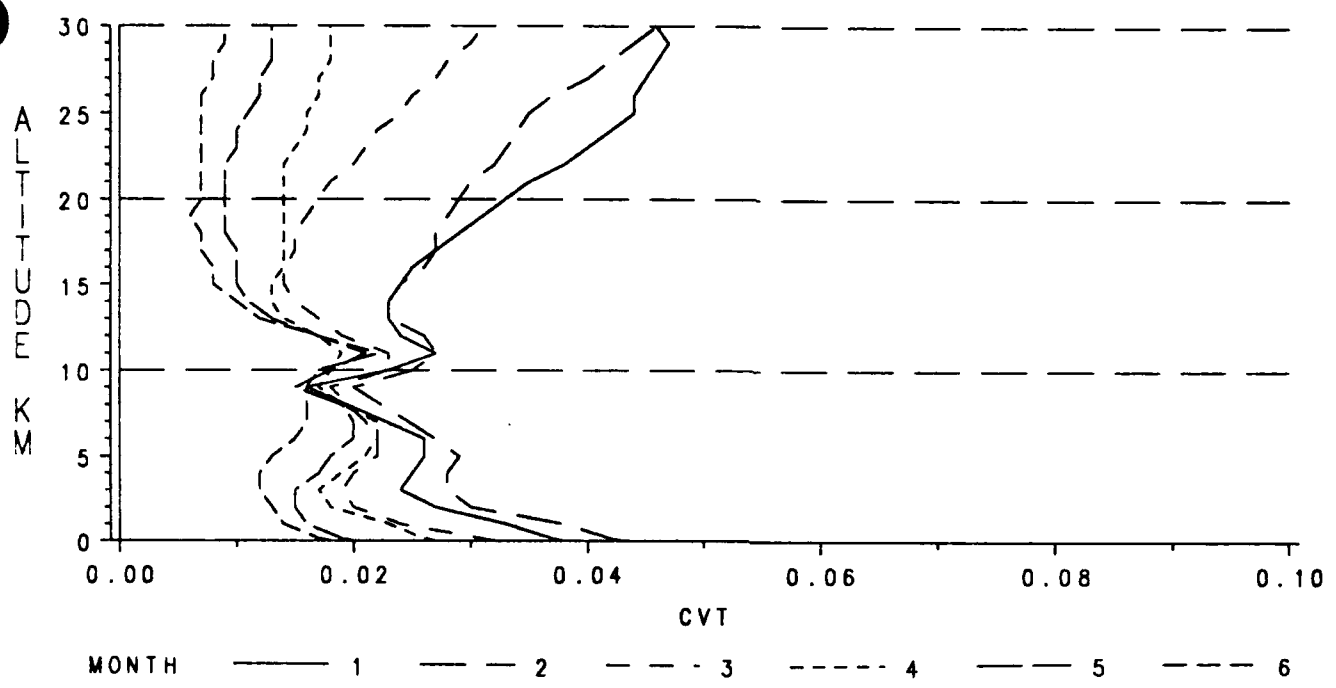

Figure F-25. Coefficients of Variation for Temperature, January-June.

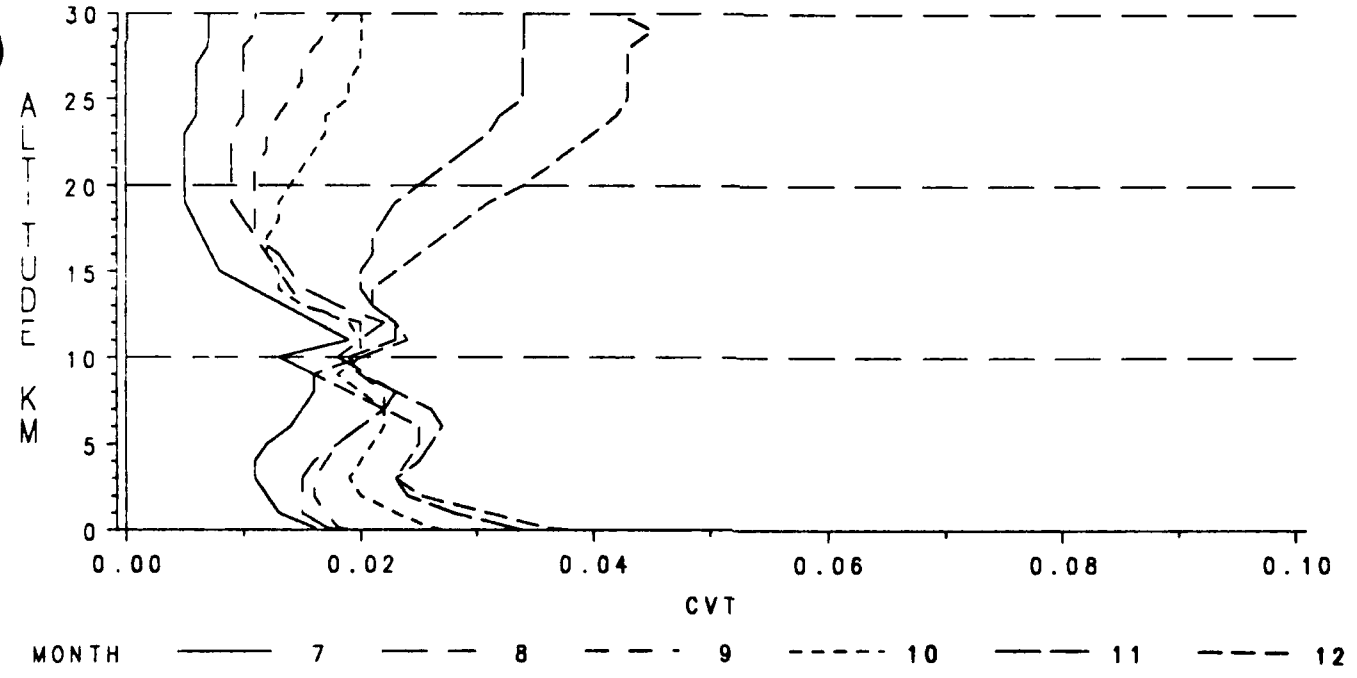

Figure F-26. Coefficients of Variation for Temperature, July-December.

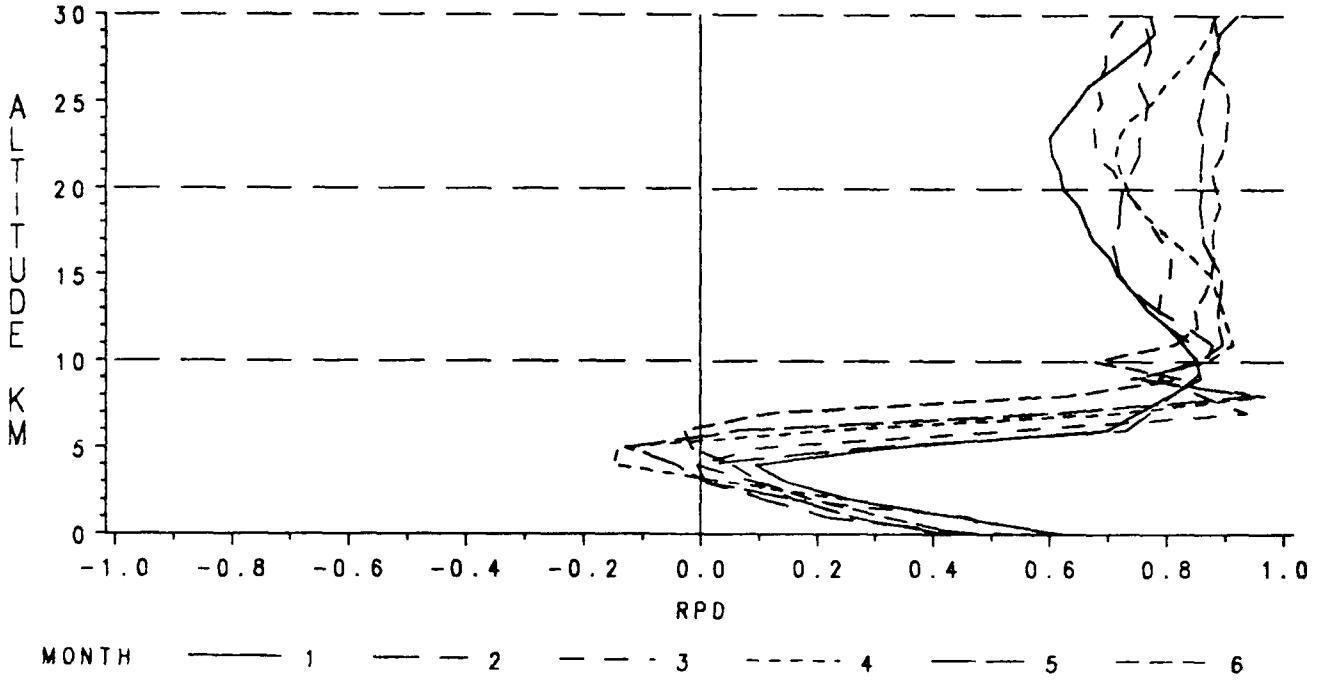

Figure F-27. Correlation Coefficients for Pressure & Density, January-June.

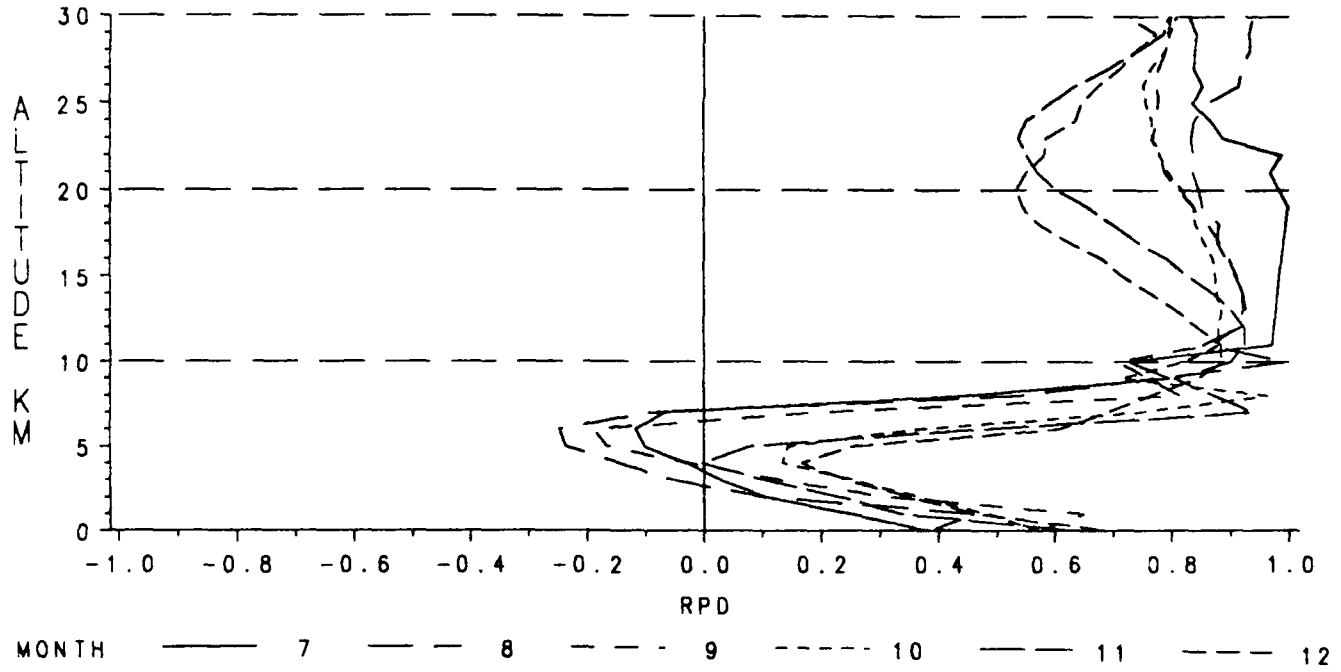

Figure F-28. Correlation Coefficients for Pressure & Density, July-December.

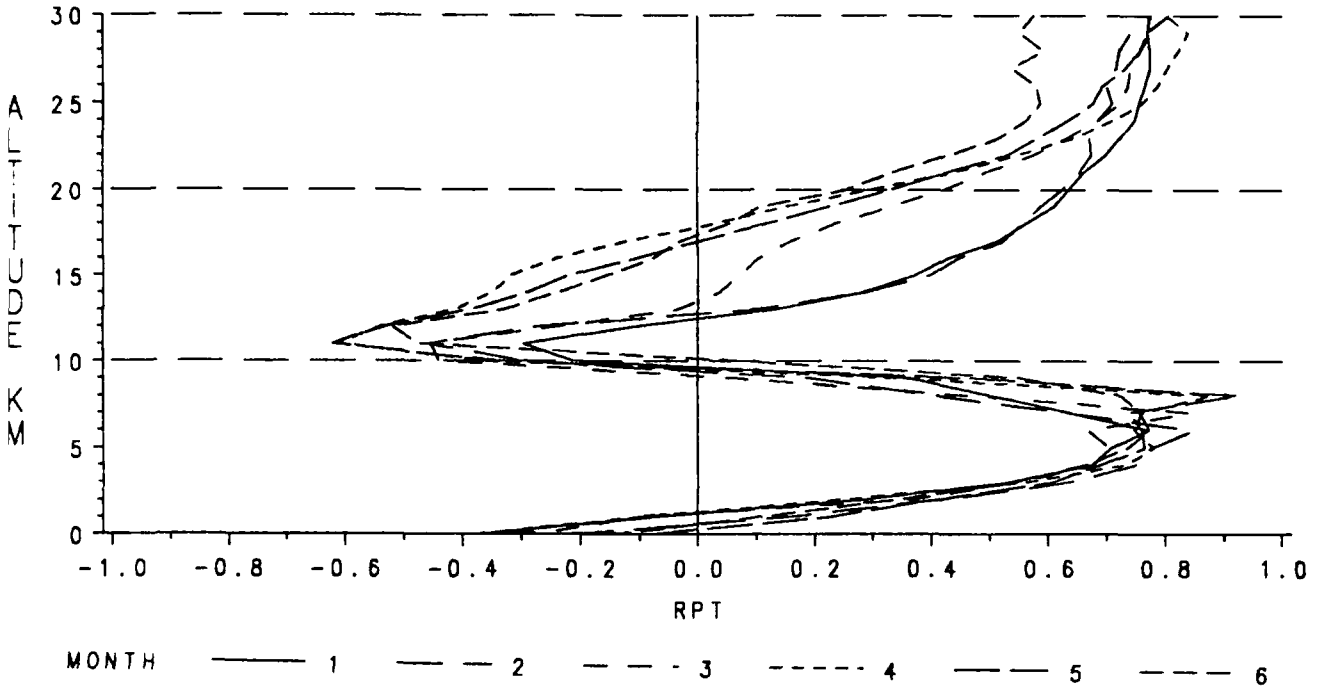

Figure F-29. Correlation Coefficients for Pressure & Temperature, January-June.

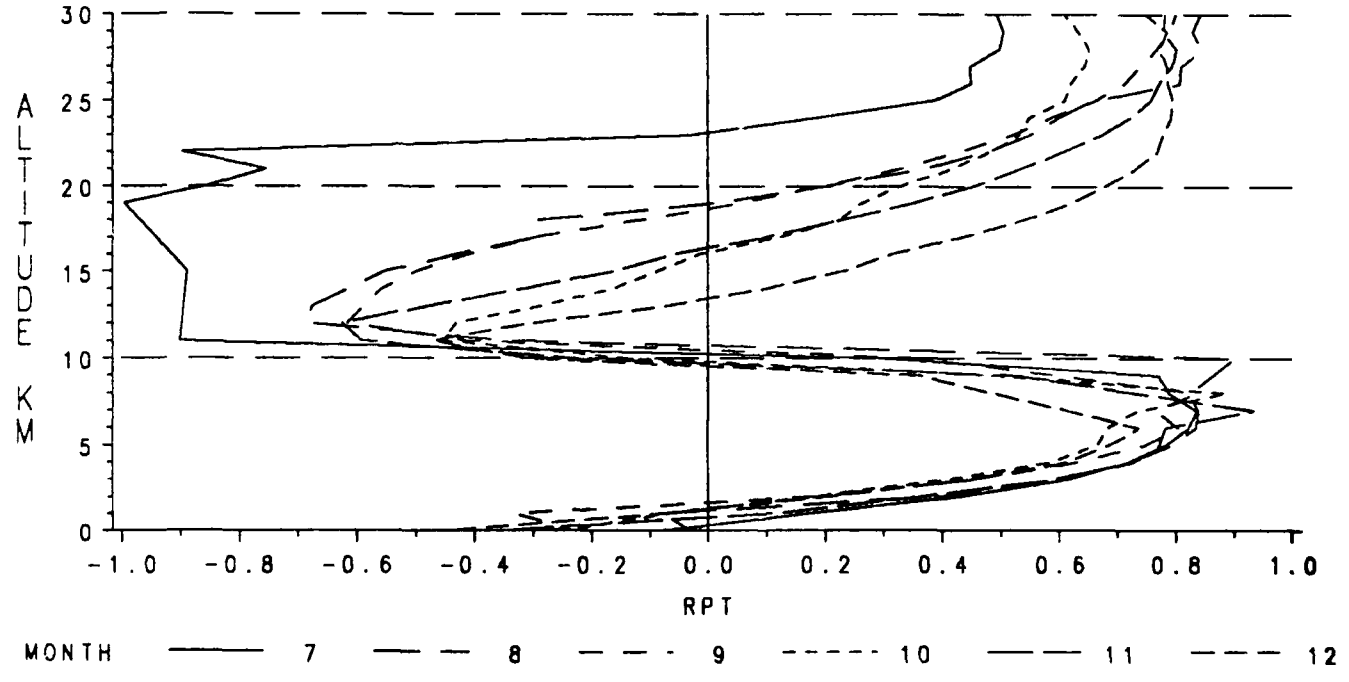

Figure F-30. Correlation Coefficients for Pressure & Temperature July-December.

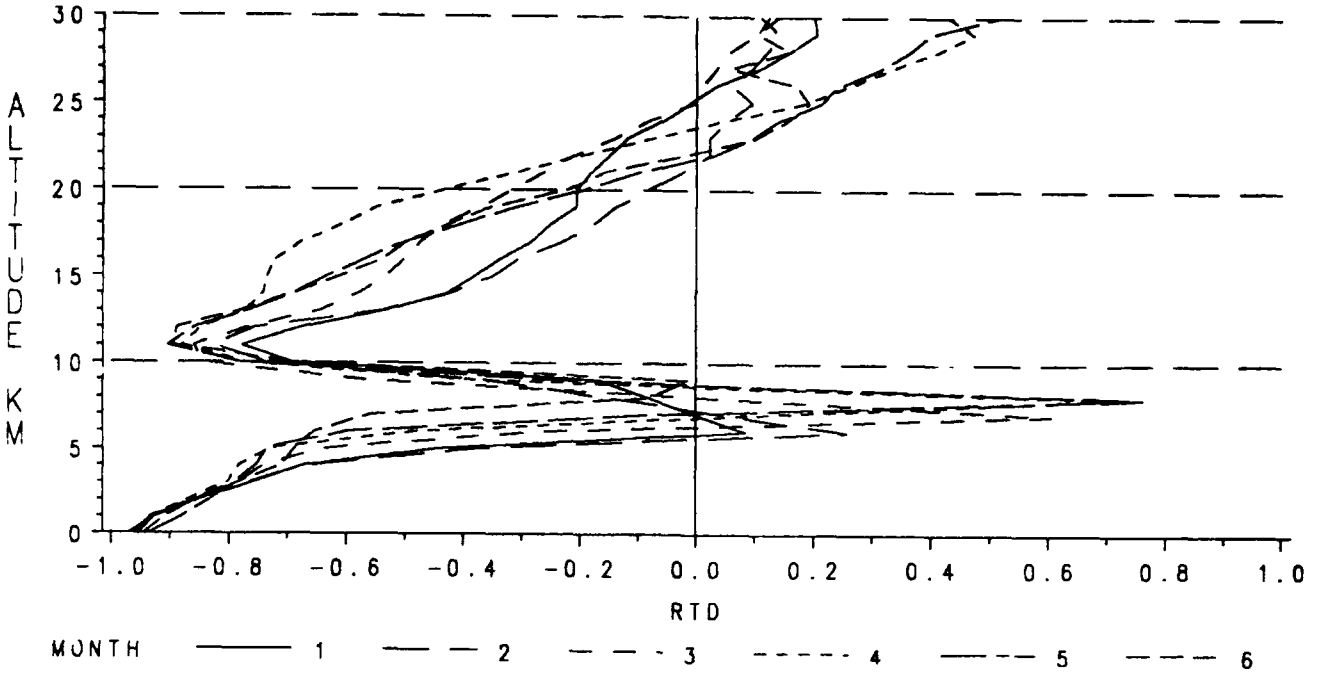

Figure F-31. Correlation Coefficients for Temperature & Density, January-June.

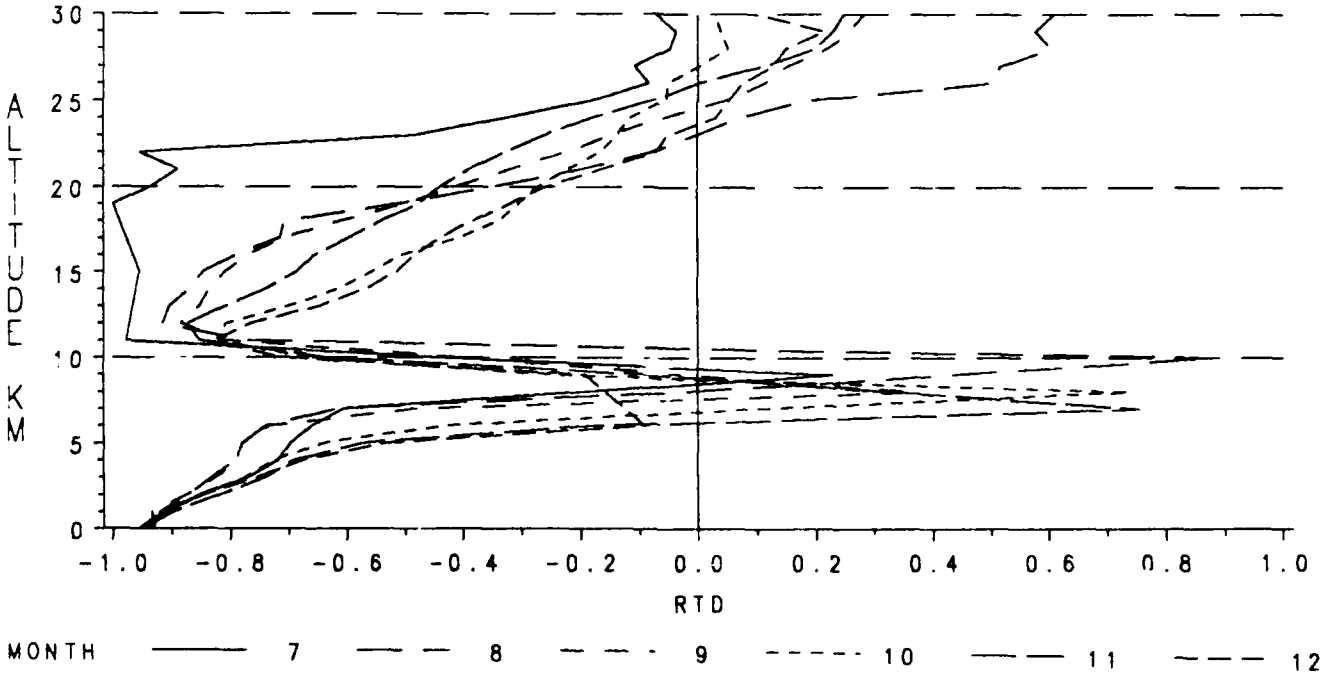

Figure F-32. Correlation Coefficients for Temperature & Density, July-December.

APPENDIX G

Fairbanks Descriptive Data

To prevent further character size reduction in the tables given in Appendices A-D, certain range-specific information for Fairbanks has been omitted. The most important information follows:

Header Record 0-30 km

Table Number	0
Data Source (1=DATSAV, 2=WDC-A)	1
Call Letters	FAI
WMO Number	702610
Latitude	64° 49'
Direction (N or S)	N
Longitude	147° 52'
Direction (E or W)	W
Elevation in Meters	138
Start Period of Record (Mo-Yr)	0173
End Period of Record (Mo-Yr)	1286
No. of Time Windows (0,1, or 2)	0
Start Time Window #1 (Hr-Mhz)	0
End Time Window #1	0
Start Time Window #2	0
End Time Window #2	0
Date of RRA	0291
Altitude Range of RRA Low-Level (km)	0
Altitude Range of RRA High-Level (km)	30
Standard Deviation of Thermodynamics Limits	±6.0
Wind Limits	±6.0

The following data is only required for RRAs that go to *70 km*:

Table Number
Data Source (1=DATSAV, 2=WDC-A)
Call Letters
WMO Number
Latitude
Direction (N or S)
Longitude
Direction (E or W)
Elevation in Meters
Start Period of Record (Mo-Yr)
End Period of Record (Mo-Yr)
No. of Time Windows (0,1, or 2)
Start Time Window #1 (Hr-Mhz)
End Time Window #1
Start Time Window #2
End Time Window #2
Date of RRA
Altitude Range of RRA Low-Level (km)
Altitude Range of RRA High-Level (km)
Standard Deviation of Thermodynamic Limits
Wind Limits

DISTRIBUTION

AWS/DO, Scott AFB, IL 62225-5008 1
AWS/XTXA, Scott AFB, IL 62225-5008 1
AWS/XTJ, Scott AFB, IL 62225-5008 1
SD/CWDA, PO Box 92960, Los Angeles, CA 90009-2960 1
Det 1, HQ AWS, Pentagon, Washington, DC 20330-6560 1
Det 2, HQ AWS, Pentagon, Washington, DC 20330-5054 1
Det 3, HQ AWS, PO Box 3430, Onizuka AFB, CA 94088-3430 1
1WW/DN, Hickam AFB, HI 96853-5000 3
    11WS/DON, Elmendorf AFB, AK 99506-5000 1
    20WS/DON, APO San Francisco 96328-5000 1
    30WS/DON, APO San Francisco 96301-0420 1
2WW/DN, APO New York 09094-5000 1
3WW/DN, Offutt AFB, NE 68113-5000 2
4WW/DN, Peterson AFB, CO 80914-5000 2
    2WS/DON, Andrews AFB, MD 20334-5000 20
5WW/DN, Langley AFB, VA 23665-5000 2
AFGWC/SDSL, Offutt AFB, NE 68113-5000 2
    USAFETAC, Scott AFB, IL 62225-5438 5
7WW/DN, Scott AFB, IL 62225-5008 1
    6WS/DON Hurlburt Field, FL 32544-5000 1
    17WS/DON, Travis AFB, CA 94535-5986 1
3350 TCHTG/TTGU-W, Stop 62, Chanute AFB, IL 61868-5000 1
3395 TCHTG/TTKO, Keesler AFB, MS 39534-5000 1
USCINCPAC (J37), Box 13, Camp H.M. Smith, HI 96861-5025 1
NAVOCEANCOMDET, Federal Building, Asheville, NC 28801-2723 1
NAVOCEANCOMDET, Patuxent River NAS, MD 20670-5103 1
NAVOCEANCOMFAC, NAS North Island, San Diego, CA 92135-5130 1
COMNAVOCEANCOM, Code N312, Stennis Space Ctr, MS 39529-5000 1
COMNAVOCEANCOM (Capt Brown, Code N332), Stennis Space Ctr, MS 39529-5001 1
NAVOCEANO, Attn Rusty Russom, Stennis Space Ctr, MS 39522-5001 2
NAVOCEANO, Code 9220 (Tony Ortolano), Stennis Space Ctr, MS 39529-5001 1
FLENUMOCEANCEN, Monterey, CA 93943-5006 1
NOARL West, Monterey, CA 93943-5006 1
Naval Research Laboratory, Code 4323, Washington, DC 20375 1
Naval Western Oceanography Ctr, Box 113, Attn: Tech Library, Pearl Harbor, HI 96860-5000 1
Naval Oceanography Command Ctr, COMNAVMAR Box 12, FPO San Francisco, CA 96630-5000 1
Pacific Missile Test Center, Geophysics Division, Code 3253, Pt Mugu, CA 93042-5000 1
NOAA Library-EOC4WSC4, Attn: ACQ, 6009 Executive Blvd, Rockville, MD 20852 1
NOAA/NESDIS (Attn: Nancy Everson, E/RA22), World Weather Bldg, Rm 703, Washington, DC 20233 1
GL/LY, Hanscom AFB, MA 01731-5000 1
GL Library, Attn: SULLR, Stop 29, Hanscom AFB, MA 01731-5000 1
Atmospheric Sciences Laboratory (SLCAS-AT-AB) Aberdeen Proving Grounds, MD 21005-5001 1
Atmospheric Sciences Laboratory, (SCLAS-AS-I), White Sands Missile Range, NM 88002-5501 1
U.S. Army Missile Command, ATTN: AMSMI-RD-TE-F, Redstone Arsenal, AL 35898-5250 1
Technical Library, Dugway Proving Ground, Dugway, UT 84022-5000 1
NCDC Library (D542X2), Federal Building, Asheville, NC 28801-2723 1
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AUL/LSE, Maxwell AFB, AL 36112-5564 1
AWSTL, Scott AFB, IL 62225-5438 50